BACTERIOLOGY FOR NURSES

HARRY W. CAREY, M.D.

HANDBOOK
OF
BACTERIOLOGY
FOR NURSES

BY

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TO THE

ALUMNÆ ASSOCIATION

OF THE

SAMARITAN HOSPITAL TRAINING
SCHOOL FOR NURSES

PREFACE TO THIRD EDITION

A great deal of advancement has been made in bacteriology since the second edition of this book appeared ten years ago. In order to incorporate the new work that has been done, it has been necessary to rewrite the entire book and to enlarge it.

Many of the subjects have been discussed in more detail than might seem to be required in a text-book for nurses but the requirements of the National League for Nursing and the State Boards of Education are more exacting than formerly.

Furthermore, nurses travel much more than formerly. Nurses are no longer a local institution. They often travel abroad with their patients and in consequence encounter diseases that do not exist at home.

I have had it in mind, therefore, to prepare a book to serve the nurse not only as a text but for reference as well.

I am indebted to Miss Mildred I. Lorenz, R. N., B. S., Instructor of Science in the School of Nursing of the Samaritan Hospital for many helpful suggestions in the preparation of the Laboratory Exercises.

I also wish to acknowledge the very valuable assistance given me by my wife both in the preparation of the manuscript and in the proof reading.

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CHAPTER I.

THE HISTORY OF BACTERIOLOGY.

The history of this science is interesting because it tells how the study of bacteria developed from mere theories into a science based upon facts. Long before anything was known of the existence of germs, references could be found in the writings of the ancient Greeks discussing the possibility of disease passing from one person to another. The agent of infection was supposed to originate from the air or moisture.

THE DISCOVERY OF GERMS.

With the instruments of ancient times it was impossible to see the minute living particles which we now know as germs; in fact, it is doubtful that such minute forms were thought of. The seventeenth century, however, marked a new era in the making of optical instruments. Anthony von Leeuwenhoeck, a linen draper of Amsterdam in Holland, in 1675, succeeded in perfecting a lens of much greater magnifying power than those hitherto in use. By means of this lens he was able to see minute living animalcules in saliva, water, and other fluids, that were smaller than any seen before. The descriptions of these animalcules were very accurate and correspond to some of the forms we recognize today.

The Theory of Spontaneous Generation.

The discovery of these minute living organisms provoked a great deal of discussion, as may be imagined. Perhaps the question most debated was their source and mode of origin. Among the lowest forms of animal life known at that time were the maggots found in putrefying meat. It was supposed that they developed from the meat during the process of putrefaction. The animalcules of von Leeuwenhoeck, too, were believed to originate spontaneously.

Experiments Proving Spontaneous Generation Incorrect.—The theory of spontaneous generation held sway, and, although there were many opposed to this doctrine, it was not until nearly a hundred years later (1769), that Spallanzani, an Italian, tried by experiment to show that micro-organisms could not develop in this way. He took animal matter and mixed it with water in a flask. After boiling the mixture and sealing the neck of the flask he found that it could be kept a long time without putrefying and without any micro-organisms developing in it. This experiment was subjected to much criticism, however, because the air so essential for the development of life was excluded by sealing the flask. This objection was met by modifying the experiment by admitting air that had passed through strong sulphuric acid.

It remained for Pasteur (1860) to settle this question beyond dispute by proving that the entrance of dust into mixtures that had been boiled was sufficient to set up putrefaction on account of the germs carried in with it. He proved this point in an ingenious way,

by drawing out the neck of the flask into fine tubes and shaping them like the letter U. The ends of the tube could be left open, admitting air, but the particles of germ-laden dust collected at the bottom of the U tube and the mixture in the flask remained free of germ growth. He obtained a similar result by using cotton to close the neck of the flask. The fine, closely-packed fibers of cotton acted as a filter for the dust and germs, keeping the contents sterile.

These experiments had a far-reaching influence upon the conception of bacteriology, as may be imagined, and proved beyond question that *germs originate only from germs.* Upon this fact rest all our ideas for preventing the spread of disease.

These experiments of Pasteur suggested to Lister in 1863 the antiseptic treatment of wounds. He made an effort to prevent or check the infection in wounds, which had added so much to the hazards of surgical operations. The work of Lister laid the foundation of our present day conception of asepsis in surgery.

ASSOCIATION OF GERMS WITH THE CAUSE OF DISEASE.

The association of micro-organisms with the production of disease, conceived long before the organisms were seen, received much attention after the observations of von Leeuwenhoeck. During the next hundred years all sorts and kinds of disease were one after another attributed to the growth of germs in the body. Von Plenciz (1762), a physician of Vienna, was perhaps the foremost advocate of these new ideas of the causation of disease. He believed not only that germs gave

rise to some diseases, but that each disease had its own particular germ which, after entering the body, developed and multiplied. These theories of von Plenciz were subjected to much ridicule to be sure; but they continued to gain adherents nevertheless, and have proven, as we know, to be correct. Some years later, Henle (1840) collected and published all the work that had been done up to that time, and pointed out that the causal relationship of germs to disease could not be proven simply by finding germs in the diseased tissues of the body, but that they must also be grown and studied outside of the body. Experiments to prove the doctrines of Henle were lacking chiefly because the instruments and methods for studying germs at that time were inadequate.

In the next thirty to forty years many new methods were introduced which marked a rapid progress in the study of germs; for example, the use of aniline dyes for coloring germs so that they could be seen better under the microscope, and solid and fluid culture media on which germs could be cultivated and different kinds separated and studied.

The Laws of Koch.—The development of these new methods was due chiefly to the genius of Koch, who also laid down certain laws or conditions which had to be fulfilled before any germ could be said to be the cause of any specific disease.

The laws or postulates of Koch were:

1. The same organism should be constantly present in that particular pathological condition.

2. The bacteria should be isolated in pure culture from the infected tissue.

3. The same pathological condition should be reproduced by inoculating animals with the bacteria.

4. The same bacteria should be recovered from the inoculated animal.

BACTERIOLOGY IN THE PREVENTION OF DISEASE.

With improved methods and appliances the relationship of germs to specific diseases could be proven experimentally, and the discovery of the germs of many diseases followed with great rapidity. Since 1879 the germs causing the following diseases have been discovered: Diphtheria, leprosy, typhoid fever, tuberculosis, tetanus (lockjaw), influenza, bubonic plague, cholera, meningitis, pneumonia, syphilis, gonorrhea, and others.

The study of the life history or biology of these germs has led to our present knowledge of the cause, the course, and the ways of preventing most of the infectious diseases, and has put into the hands of physicians the means whereby the character of an infectious disease may be detected. Furthermore, it has made modern surgery possible. Our knowledge of the ways that wounds may become contaminated and how this may be prevented has been the greatest factor in the development of surgical operations and has made the danger of infection in surgery almost negligible.

From this brief sketch it is easy to appreciate that bacteriology is, comparatively speaking, a new science, and that its greatest progress has occurred in our time. It is advancing now even more rapidly than ever before along lines destined to be of the greatest service

to humanity. Efforts are being directed particularly to the discovery of antitoxins and serums that will protect against the infectious diseases.

Questions in Review.

1. When were germs first seen and by whom?

2. What was the theory of spontaneous generation?

3. What experiments proved that the theory of spontaneous generation was wrong?

4. What observations of Pasteur also proved this theory wrong?

5. What are the laws of Koch?

CHAPTER II.

THE CLASSIFICATION, MORPHOLOGY, BIOLOGY, AND DISTRIBUTION OF BACTERIA.

CLASSIFICATION OF BACTERIA.

We have referred to micro-organisms as germs, a popular term, but not exact enough for our use. The

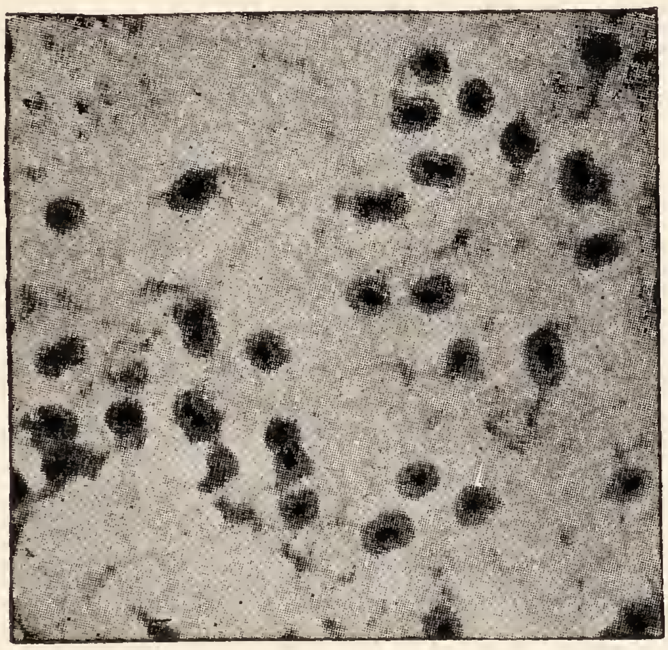


Fig. 1.—Bacterial capsules. (Zinsser. D. Appleton & Co.)

term "germs" may be taken to mean any microscopic organism, animal or vegetable.

Animal.—In the animal kingdom the lowest forms of life are called protozoa (sing. protozoön), of which there are several types: Sarcodina, mastigophora, and sporozoa. The discussion of the protozoa will be reserved until a later chapter. (See Chapter XVIII.)

Vegetable.—In the vegetable kingdom we are particularly interested in the fungi, which are subdivided into hyphomycetes or molds, blastomycetes or yeasts,

and schizomycetes or bacteria. The bacteria are by far the most important of the three; so we will confine ourselves solely to them for the present, and leave the yeasts and molds for a subsequent chapter. (See Chapter XVI.)

Definition of Bacterium.—The word bacterium is derived from a Greek word meaning a rod; the plural form is bacteria. A bacterium may be defined as a minute living organism composed of one cell, belonging to the vegetable kingdom.

Structure.—The structure of the bacterial cell is difficult to make out but it seems to be but a mass of protoplasm. When viewed under the microscope in the natural state, bacteria are colorless, refractive, bodies. If they are stained with aniline dyes their outline becomes much more distinct and a cell membrane or covering can be distinguished. In some bacteria the cell membrane is much thickened and constitutes a capsule, the increased density of which makes the penetration of dyes difficult.

MORPHOLOGY.

The morphological characters of bacteria—that is, their size and shape—vary greatly, and upon this basis it is convenient to subdivide them into three types:

A. Coccus; plural form, cocci.

B. Bacillus; plural form, bacilli.

C. Spirillum; plural form, spirilla.

The *cocci* are shaped like berries, that is, about spherical. They may be flattened on one side or concave, or split like a coffee-bean. They may be arranged in pairs called diplococci; in fours, tetracocci;

Fig. 2.—Different forms of bacteria. *A,* cocci; *B,* bacilli; *C,* spirilla. (*Baumgarten.*)

or in cubes, sarcinæ. They are commonly arranged in long strings or chains termed streptococci, or in masses, often likened to bunches of grapes, staphylococci. The *bacilli* are rod-shaped, sometimes slightly curved, and vary greatly in length, from $1/1000$ to $1/25000$ of an inch. They are slender or thick. Some have rounded ends, some are square at the end. A bacillus usually is of uniform width but a few are quite irregular in this respect. They occasionally form in chains or rows. The *spirilla* are spiral or corkscrew-shaped, as the name implies. Some may be comma-shaped. They vary both in length and in the number of spirals. Of these three types the bacilli are by far the most numerous and the spirilla the least numerous. The types are not interchangeable; so it is not possible for a coccus to become a bacillus or a bacillus a spirillum.

Questions in Review.

1. Define a bacterium. What is its structure?

2. How may bacteria be classified on the basis of their shape?

3. Describe the arrangement of—staphylococci, streptococci, diplococci, tetracocci and sarcinæ.

4. What class of bacteria exist in greatest number? What class in least number?

CHAPTER III.

MICROSCOPIC EXAMINATION OF BACTERIA.

THE MICROSCOPE.

In order to see bacteria it is necessary to use a microscope of high magnifying power; indeed it is highly probable that some forms of bacteria are so small that they cannot be seen except by the ultra-microscope which has extremely high magnification.

The microscope consists of two main parts, one is the lens system, the other is the stand and adjusting system.

The Lenses.—The lens system is supported by the body tube. At the upper end of this is the ocular (*A*) which contains two lenses, one at the top and one at the bottom. Oculars numbered 2 and 4 are most used, the latter giving the greater magnification. They are removable. At the lower end are the objectives (*B*), usually three, which are attached to a revolving nose piece in such a way that they may be swung into place as desired. The objectives contain lenses which give the principal magnification of the object. They are, in the order of their magnifying power, the one-fourth or low power dry, the one-sixth or high power dry, and the one-twelfth or oil immersion.

The Stand and Adjusting System.—The stand rests on a heavy base in which there is a joint by which the microscope may be tilted back. This is rarely used in bacteriological work. The stage (*C*) with central

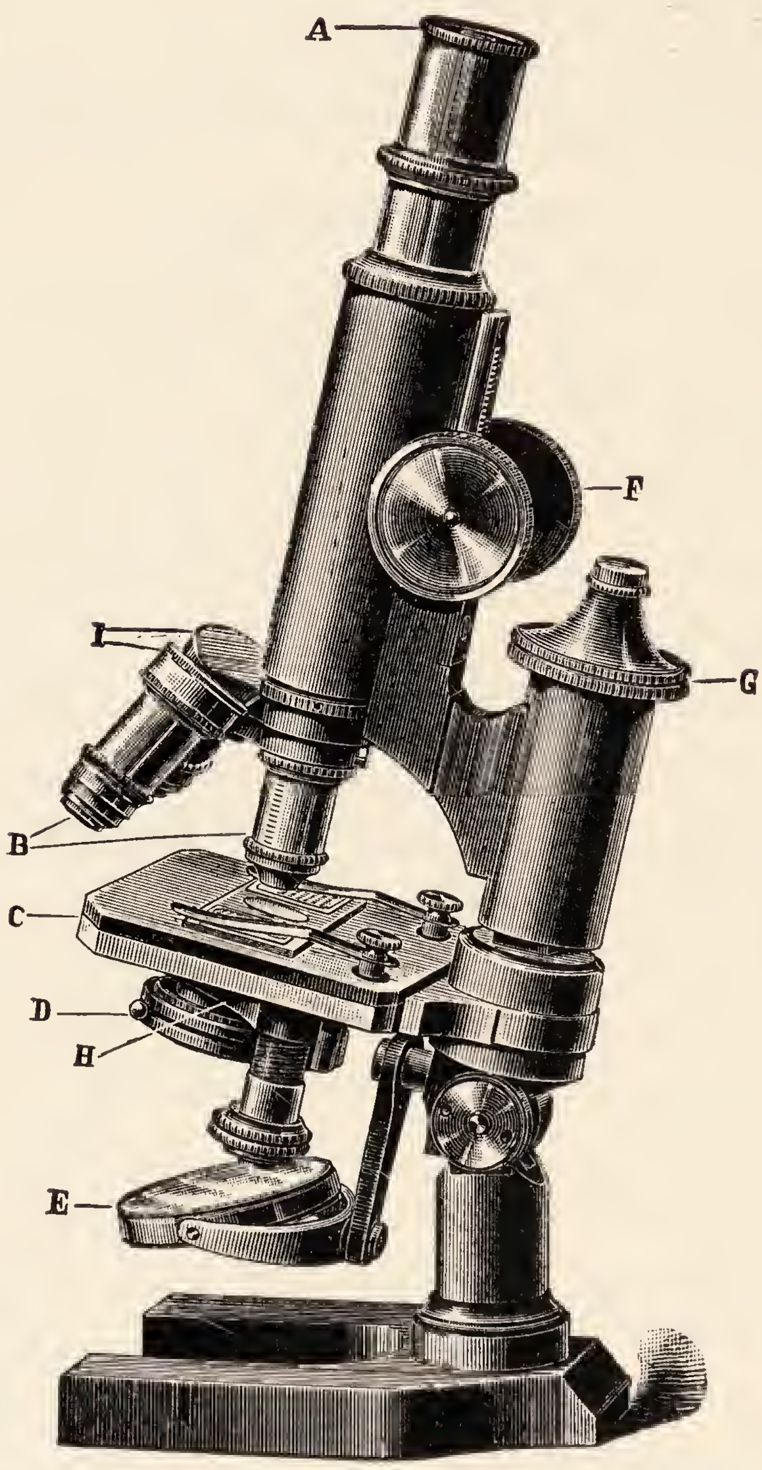


Fig. 3 (*a*).—The microscope. *A,* eye-piece (or ocular, usually there are four, numbered 1 to 4); *B,* the lens (or objective); *C,* the platform (or stage); *D,* the iris diaphragm; *E,* reflector or mirror; *F,* coarse adjustment; *G,* fine adjustment.

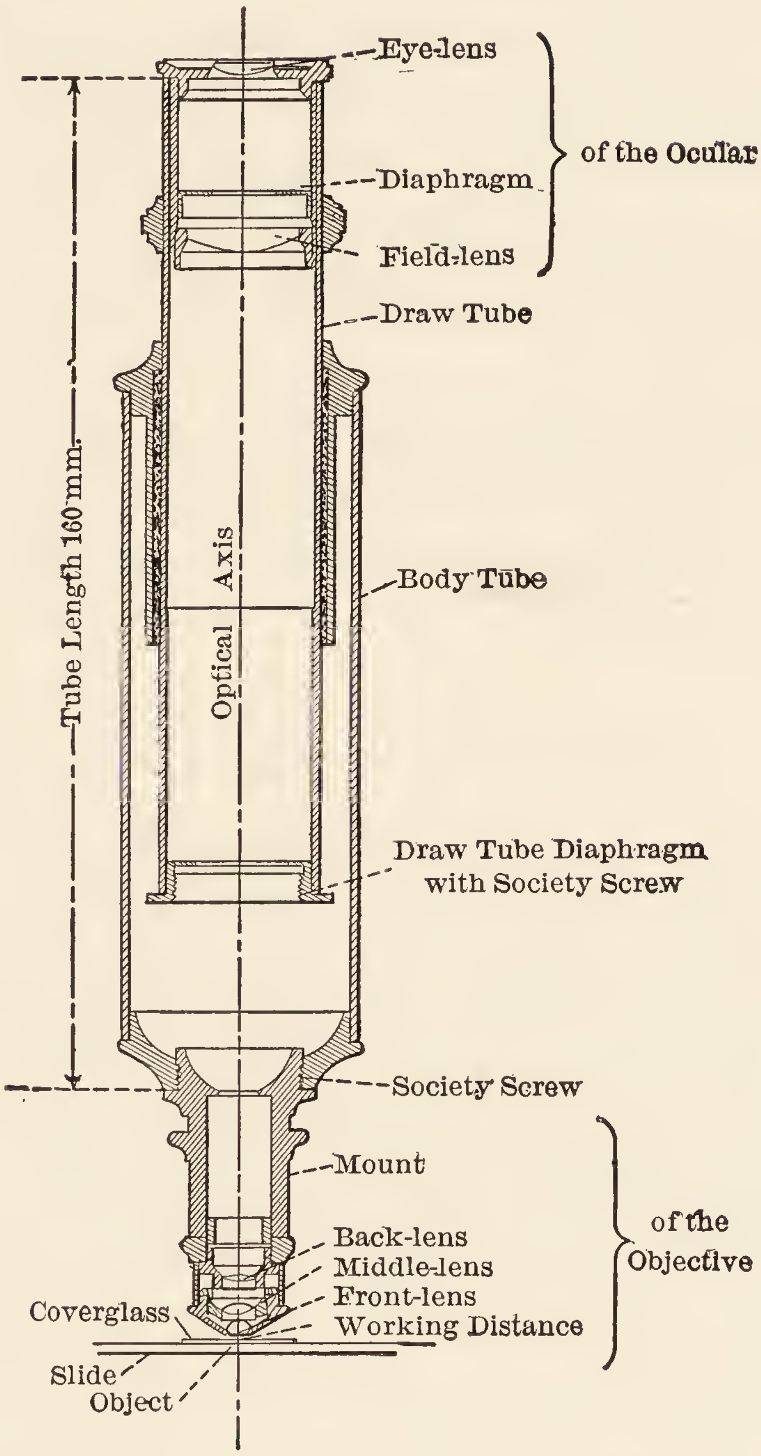


Fig. 3 (*b*).—Internal structure of the microscope.

opening supports the preparation to be examined. Many microscopes have mechanical stages on which the object may be moved about by screws. Beneath the stage is the Abbè condenser consisting of a thick lens for concentrating the light reflected by the mirror (*E*) beneath. The iris diaphragm (*D*), on the under side of the Abbè condenser controls the amount of light coming from the mirror. It opens and closes like the iris of the eye.

The upright above the stage supports the body tube and two focusing devices which raise and lower the tube bearing the lenses. They are the coarse and fine adjustment (*F, G*).

How to Use the Microscope.

Place the instrument so that it faces the light. Northern light is the best. Never place the microscope facing into the sunlight. Now look down through the tube, holding the eye close to the ocular, and tilt the mirror so that it will reflect the maximum amount of light upward through the Abbè condenser. When this has been done, place the slide bearing the object on the stage so that the object is directly beneath the objective and over the opening in the stage. While looking through the ocular, move the tube up or down by the coarse adjustment until the object appears in the field. The object can be seen more clearly by focusing with the fine adjustment. This is done by turning the adjusting screw a little one way or the other, thus raising or lowering the objective. In focusing never use force. Any resistance met with

means either that the lens of the objective is lying against the slide or that the limit of focusing movement has been reached. In either case force may do serious damage to the microscope.

If higher magnification is desired, the one-sixth or high dry objective is swung into position without disturbing the object, and if the microscope is properly constructed, it will nearly focus. By moving the coarse adjustment a very little, the object will again come into view but with much greater magnification. The fine adjustment is used again to focus more closely.

If still greater magnification is necessary, the one-twelfth or oil immersion objective is turned into place. It is necessary to have this lens immersed in cedar wood oil in order to see the object clearly. The oil has the same index of refraction as the lens and so there is no loss of light by deflection. Focusing is done in the same manner as described above but the distance the lens has to be raised or lowered is very small.

For larger objects, like colonies of bacteria, or for locating objects, the one-fourth objective is used. The high dry, or one-sixth objective may be used for studying bacteria, particularly unstained bacteria in fluids. The oil immersion or one-twelfth objective is generally used for the study of bacteria. When examining unstained objects it is necessary to have the field somewhat darkened. This is done by partly closing the iris diaphragm. Artificial light will be found better than daylight for viewing unstained objects.

Taking Care of the Microscope.

After using the microscope, the lens should be cleaned with Japanese lens paper. The immersion lens must be cleaned carefully as the oil is likely to dry on it. When this happens the oil may be removed with xylol or chloroform and dried at once with lens paper. When not in use the microscope should be covered with a hood or placed in the microscope box. The moving parts must be kept lubricated with paraffin oil.

METHODS OF CULTIVATING MICRO-ORGANISMS AND PREPARING THEM FOR MICROSCOPIC EXAMINATION.

In the bacteriological laboratory bacteria must be handled in such a way as to protect the worker and to prevent the bacteria from being scattered about. This applies to pathogenic bacteria particularly.

Smears on Glass Stains.—For direct examination of sputum, pus, and so on, smears on glass slides are made. This is done by removing a small amount of the material with a platinum or nichrome wire loop, and spreading it thinly on the slide. The loop and wire, as far as the handle, are put into the flame of a Bunsen burner until it is red hot. It is allowed to cool and then used. After use, the loop is at once burned off again. The slide is now passed several times through the flame to fix the material on the slide so that it will not wash off during the process of staining.

From Culture Media.—When bacterial growth in culture media is to be examined in smears the cotton plugs are twisted out of the tubes between the fourth

Fig. 4.—Taking plugs from tubes before inoculation. (Zinsser. D. Appleton & Co.)

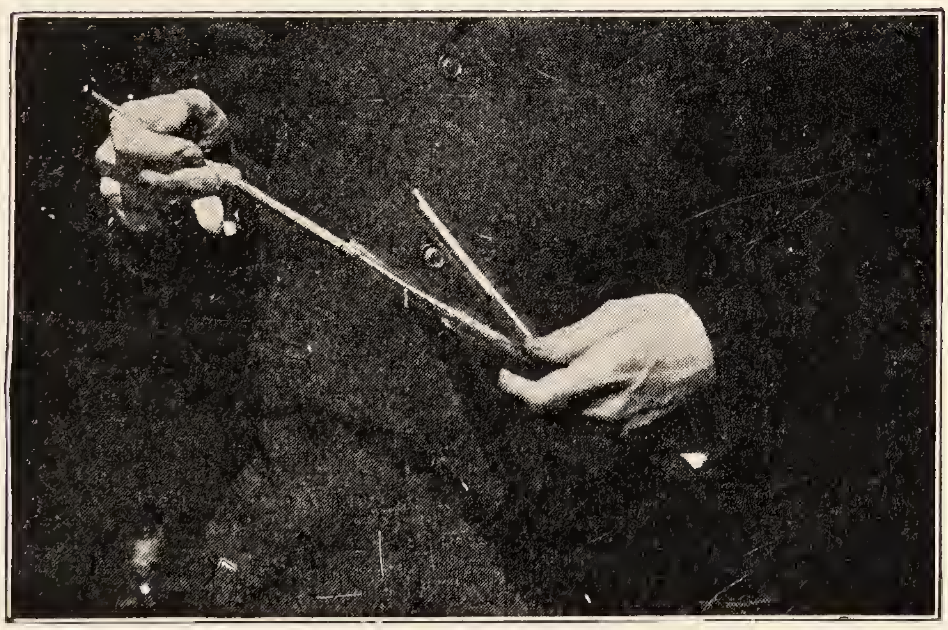


Fig. 5.—Inoculating. (Zinsser. D. Appleton & Co.)

and fifth fingers of the right hand, while the culture tube is held by the left hand. The culture tube is now placed between the first finger and thumb of the left hand with the open end to the right (Figs. 4 and 5). The wire loop is now burned off and the smear made as described. After use the loop is burned off again. The cotton plugs are now replaced in the tubes.

Hanging Drops.—To examine cultures of bacteria unstained or to determine motility, a hanging drop is prepared. This is done by first rimming a cover glass with vaseline, then a drop of the fluid culture is placed in the center of the cover glass. It is now turned up-

Fig. 6.—Hanging drop slide with cover glass. (Park and Williams. Lea & Febiger.)

side down in such a way that the drop will fit into the center of the concave part of the slide, and the edges pressed down. This seals the preparation so that the drop will not dry up. The hanging drop preparation is used for agglutination tests, so that the clumping and motility can be observed.

Isolation of Bacteria.

Plate Cultures.—The isolation of the different kinds of bacteria from material that contains two or more varieties is done by means of plate cultures. For this purpose petri dishes are used. They are round, rather shallow, glass dishes in two parts; the glass cover telescopes over the under plate and fits closely. This admits air but not bacteria.

Solid culture media is melted in the water bath and cooled to 44° C. It is now ready to be inoculated. A loopful of the material is taken up with the loop and placed in the culture medium. The mouth of the culture tube is passed through the flame of the Bunsen burner. The cover of the petri dish is raised enough on one side to allow the culture medium to be poured in. It is allowed to stand in order to become solid,

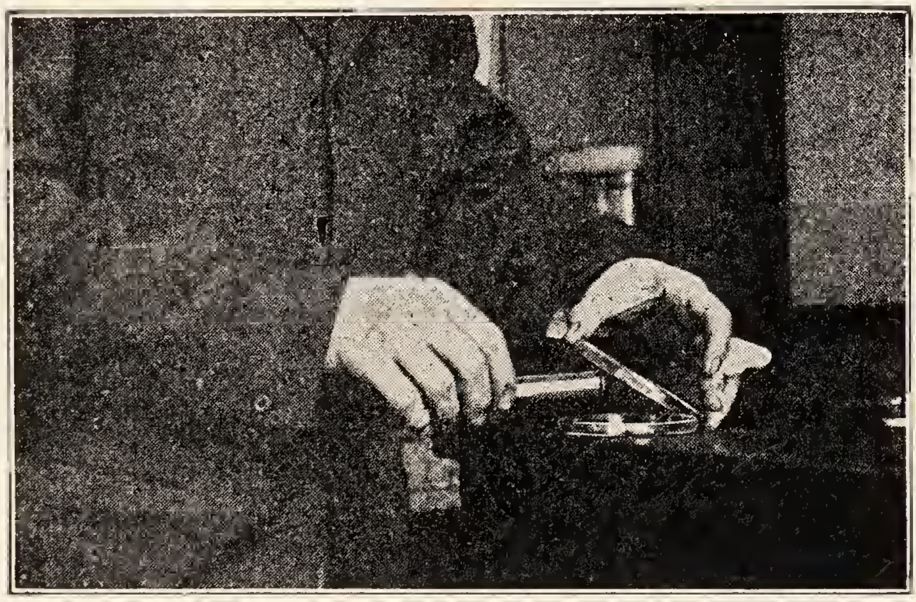


Fig. 7.—Pouring inoculating medium from petri dish. (Zinsser. D. Appleton & Co.)

then turned upside down, and placed in the incubator. After twenty-four hours incubation, the plate is examined. Each bacterium scattered through the culture will have multiplied to form a colony; and the colonies can be seen here and there in the plate. Individual colonies can be "fished" by means of an inoculating needle. The point of the needle, after burning if off, is introduced into a colony, a little taken up and transferred to a fresh culture tube. In this way the different kinds of bacteria may be separated and are ready to be studied in order to identify them.

Streaking.—Another way of isolating bacteria is by streaking. A loopful of the material is drawn or streaked over the surface of solid culture medium in a petri dish. The whole plate may be streaked in parallel lines with one loopful. After incubation the colonies are found most numerous in the streaks made first. In the streaks made last, the colonies are separated sufficiently to be "fished."

Counting.—Plate cultures of milk and water are made in order to count the number of bacteria contained in them. The colonies are counted by placing the petri dish over a glass plate ruled into squares, one square centimeter each. It is not necessary to count all the squares if the bacteria are in large number. A portion of the plate may be counted and the average number of bacteria in a square calculated. This number is multiplied by the whole number of squares in the plate.

Glassware Required.

The glassware needed consists of pipettes, test-tubes, flasks, fermentation tubes, bottles, petri dishes or plates, slides and cover glasses. All glass used must be perfectly clean. It should be boiled one hour in water containing strong soap powder, rinsed thoroughly in clean water, and then sterilized in the hot air sterilizer or autoclaved. Test-tubes, fermentation tubes, flasks, and bottles must be plugged with cotton before being sterilized. Cover glasses and slides may be cleaned in alcohol and ether and then dried.

Questions in Review.

1. How should the lenses of the microscope be cleaned?

How should the microscope be carried in the laboratory?

2. Point out on the microscope and explain the use of the ocular, the objectives, the coarse and fine adjustment, the Abbè condenser, the iris diaphragm, and the reflector.

3. Why must oil be used with the oil immersion lens?

4. In what ways may an object in the field of the microscope be made to appear larger?

5. In what ways may the field be made lighter and darker?

6. Why are unstained objects more distinctly seen when the amount of light is cut down? Why can they be seen better with artificial than with daylight?

7. Why should the inoculating needle and loop be burned off before and after use?

8. What is the best way to sterilize laboratory glassware?

9. What information may be gained by the study of smears? Of hanging drops?

10. How may two or more varieties of bacteria existing together be separated?

CHAPTER IV.

THE BIOLOGY, PROPERTIES, DISTRIBUTION, AND FUNCTION OF BACTERIA.

REPRODUCTION.

Bacteria reproduce by what is known as cleavage or binary fusion; that means a pinching off or splitting in the middle, each part developing into another organism. The two parts of a dividing bacillus or spirillum may separate completely or may remain attached, giving rise to chains, characteristic of some species. The cocci may divide in one plane to form pairs or strings. They may divide in several planes to form clusters or groups. Reproduction takes place only under conditions of temperature, moisture, and nutriment favorable for growth. The rate of reproduction may be very rapid, as often as every twenty minutes for the *Bacillus coli communis.* From one organism dividing at this rate about 1600 trillions would develop in twenty-four hours.

SPORE FORMATION.

Under conditions unfavorable to the life and growth, some kinds of bacteria may assume another form to avoid extermination. This is called spore formation. These spores are round or oval bodies, much smaller than the organisms from which they originate, and differ from them in having a thick protective capsule that enables them to withstand heat, sunlight, and, in fact,

any harmful influence. The spores may be formed inside the body of the organism and extruded from it, or the whole organism may be changed into a spore. As a rule, one forms in each organism, either in the center or at the end. Occasionally more than one spore may form in a single bacterium. Spore formation, however, must not be interpreted as a form of reproduction. The position of the spore in the bacterium is characteristic of some species. The tetanus spore is always at the

Fig. 8.—Bacillus subtilis showing spores. × 1000. (Park and Williams, after *Fränke.* Lea & Febiger.)

end, while the spore of the anthrax bacillus is located at the center. When conditions again become favorable for growth the spore may elongate and gradually assume its original shape, or the bacillus may form inside the body of the spore and burst the capsule.

MOTILITY.

The power of locomotion is observed in some bacteria. When watched under the microscope they may be seen moving across the field of vision. The motility depends upon small, thread-like processes projecting

from the bodies of the bacteria, called flagella (singular form, flagellum), which, by moving to and fro with a whip-like motion propel the bodies forward. The flagella may be single or multiple, and may be placed at one or both ends or all around the bacterium. Bacteria that possess the power of motion are spoken of as motile bacteria. Motility is governed by environment, for motion is lost when the conditions of life are un-

Fig. 9.—*A,* bacilli showing one polar flagellum. *B,* bacilli showing multiple flagella. (Park and Williams. Lea & Febiger.)

favorable and is most active when they are favorable. The property of locomotion is limited to bacilli and spirilla; the cocci do not move.

PROPERTIES OF BACTERIA.

The property of producing pigment or coloring matter is peculiar to some kinds of bacteria. They are called chromo-bacteria. The color produced by each species is always the same and is distinctive. In general the pigment is in the form of small fatty globules

outside the bacteria. The common producers of pigment of this kind are the *Staphylococcus pyogenes aureus* and the *Bacillus prodigiosus.* The *Bacillus pyocyaneus* produces a greenish pigment that is water soluble and diffuses through the culture medium.

Staining.

Bacteria exhibit wide variations in the way they stain with aniline dyes. This is not due to the concentration of the dye used but depends on the chemical combinations formed by the dye with the body of the bacterium. Most bacteria stain readily but some are hard to stain, notably the *Bacillus tuberculosis.* As a rule bacteria that are hard to stain are hard to decolorize. Spores and flagella are difficult to stain and require special staining methods.

The dyes most commonly used in the staining of bacteria are: Methylene blue, basic and acid fuchsin, eosin, and gentian and methyl violet. They are prepared in solutions of appropriate strength for staining purposes.

The Gram Stain.—Some bacteria have selective staining properties. The staining of bacteria after the method of Gram, which plays such an important rôle in the identification of bacteria, illustrates this selective action. The method depends upon the action of an iodine solution in fixing an aniline dye (Sterling's gentian violet) in the bodies of some bacteria so that it cannot be removed by decolorization with alcohol. Those bacteria in which the dye is fixed are called Gram-positive, and those in which it is not fixed are called Gram-negative. By this staining method it is possible to

divide all bacteria into two groups, Gram-positive and Gram-negative according to their selective staining properties. (A more detailed description of the technic of the Gram stain will be found in the Chapter on Laboratory Exercises.)

Table Showing the Gram-positive and Gram-negative Micro-organisms.

	Gram-positive.	*Gram-negative.*
Cocci.	Staphylococcus (all types). Streptococcus (all types). Pneumococcus.	Meningococcus. Gonococcus. Micrococcus catarrhalis.
Bacilli.	B. diphtheria. B. tetanus. B. tuberculosis. B. anthracis. B. leprosy.	B. coli. B. typhosus and paratyphosus. B. dysenteriæ. B. proteus. B. mucosus capsulatus. B. pyocyaneus. B. influenzæ. B. pertussis. B. fusiformis. B. malleus.
Spirilla.	B. cholera. Treponema pallidum.	None.

Other Properties of Bacteria.

Sugar Fermentation.—Some bacteria have the property of fermenting sugar with the formation of the gases hydrogen and carbon dioxide. When the fermentative property is to be tested for, the bacteria are grown in fluid culture media containing the various

sugars, in fermentation tubes. If any gas forms it collects in the arm of the tube. The proportionate amounts of hydrogen and carbon dioxide can be measured. If a 10 per cent. solution of sodium hydroxide is mixed with the culture the carbon dioxide will be absorbed and the remaining gas is hydrogen.

Coagulation.—The property of producing acids and of coagulating proteids can be demonstrated by growing the bacteria in milk that contains litmus. When acid is formed the medium turns red and the milk clots.

Hemolysis.—A few species of bacteria have the property of dissolving red blood cells. This is called hemolysis. If hemolytic bacteria are grown on solid culture media containing blood, the growth will be surrounded by a clear colorless zone showing that the blood has been dissolved.

Identification.—From what has been said of the properties of bacteria it is possible to make a number of classifications; for example, there are the spore forming and non-spore forming bacteria; motile and non-motile; fermenting and non-fermenting; acid forming and alkali forming; hemolytic and non-hemolytic. The classification of the bacteria into Gram-positive and Gram-negative groups is a very important one. By observing these properties of bacteria it is possible to identify them.

NUTRIMENT FOR BACTERIA.

Culture Media.—Like all plants bacteria require food, which must be in very simple form to enable them to assimilate it. Nutriment can be made in the laboratory and is called culture media. It may be either solid

or fluid. It must contain the chemical elements, oxygen, carbon, nitrogen, hydrogen and chemical salts. The basis of culture media is usually a watery extract of meat which contains albumin extractives, carbohydrates, and chemical salts. As the albumins in the watery extract are destroyed by heat, they are replaced by the addition of proteid called peptone. If a solid medium is desired, agar-agar, gelatin, or blood-serum is added.

Special Media.—From this basic medium numerous special media may be made. Various sugars, blood serum, whole blood, and ascitic fluid make the medium richer while bile and the aniline dyes, like gentian violet, methylene blue, eosin, brilliant green, and fuchsin all act to check the growth of certain bacteria. The dye medium is specially valuable in cultures of stools where typhoid is suspected because the typhoid and paratyphoid bacilli are little affected by the dye while the other bacteria, always present in stools, are checked. The amount of acid present in the media is of much importance because most bacteria will not thrive unless the medium is neutral or slightly alkaline. It is necessary then to determine the chemical reaction of the culture medium and bring it to neutral by the addition of acid or alkali as the case may be.

Sterilization of Media.—When the media has been prepared it must be placed in suitable containers of glass, such as test-tubes, flasks, bottles, and fermentation tubes which are plugged with cotton and sterilized by steam under fifteen pounds pressure (autoclave) for twenty minutes. The sterilizer used in the operating room may be used for this purpose but care should be

used at the end of the sterilization not to allow the steam to blow off rapidly as this is liable to suck the cotton plugs out of the tubes or flasks containing the media. In the case of culture media containing sugars the autoclave cannot be used because the intense heat changes the composition of the sugar. For sterilization of sugar media live steam is used in an Arnold sterilizer (Figs. 11, 12 and 13). An exposure to the steam for thirty minutes is required on each of three successive days.

INFLUENCE OF ENVIRONMENT.

Some bacteria derive the oxygen from the air, while others take it from substances in which the oxygen is combined with other chemical elements. The bacteria that take their oxygen from the air are called *aërobic bacteria,* while those taking it from substances containing it in combined form are called *anaërobic bacteria.* The line of demarcation between the aërobic and the anaërobic bacteria is not fixed, as sometimes bacteria thriving best under aërobic conditions will, nevertheless, grow in the absence of free oxygen and *vice versa.* These are spoken of as *facultative anaërobes* or *aërobes,* as the case may be. The carbon is obtained from proteids, carbohydrates (starchy substances), or fats. The hydrogen is derived for the most part from water. The nitrogen is obtained from proteids such as albumin. The salts required for nutrition are sodium, potassium, and magnesium.

Temperature.—Certain conditions of environment exert a great deal of influence upon the life and growth of bacteria. The influence of temperature is most im-

portant. Most bacteria thrive best at 37.5° C., and as the temperature varies above or below this point, growth is retarded. A temperature of 62° C. will kill most bacteria. Low temperatures are not so destructive, for by experiments it has been proven that a temperature of 200° below zero (Centigrade) will not kill all bacteria.

DISTRIBUTION OF BACTERIA.

The distribution of bacteria in nature is practically universal. They are found in the soil, in the air, and in water. In fact, wherever plants and animals live bacteria are found. Their distribution, however, is not uniform. The soil is the chief home or habitat of bacteria on account of the large amount of animal matter in it. Bacteria may also reach the soil from the air, contaminated water, excreta of men and animals, and decaying vegetable matter. They are most numerous in the soil about cesspools and manured fields. They are much more plentiful in cultivated than in uncultivated land. It has been estimated that cultivated land contains 1,500,000 bacteria per gram and uncultivated land 100,000 bacteria per gram.

Soil.—They are present in greatest number in the surface soil and diminish rapidly in the deeper layers. This is due partly to the lower temperature in the deeper layers and partly to the closely packed particles of the soil which will not permit the bacteria to penetrate beyond the superficial layers. For this reason surface water, which contains great numbers of bacteria, is rendered practically free from them at a depth of six feet.

Air.—The air contains large numbers of bacteria in densely populated cities, in theaters, churches and meeting halls where many people congregate. After the winter, when snow has covered the ground for long periods, large amounts of dirt accumulate and the high winds of the spring blow the dust with the bacteria into the air.

The bacteria in the soil and air do not exist as a rule in their true form, but as spores which develop into bacteria when the conditions for growth become favorable.

Water.—Water as it leaves the clouds in the form of rain is free from bacteria, but as the rain drops approach the earth particles of dust adhere to them. Snowflakes are contaminated with bacteria in the same way. The surface waters, in streams, ponds, and lakes contain great numbers of bacteria due to the soil that is mixed with them. Streams and lakes situated in thickly populated areas contain more bacteria than those located in rural sections. The decaying vegetation in these surface waters feed the bacteria.

Food Contamination.

Foods become contaminated with bacteria in a variety of ways. Vegetables always have the soil bacteria on their surface. Meats, if exposed to the air, take up bacteria from the dust. The surfaces of fruit become contaminated with bacteria in the same way. In order to diminish the contamination of foods as much as possible, ordinances are in force in many cities that require meats, fruits, candies, etc., to be covered with glass when displayed for sale.

FUNCTION OF BACTERIA.

With bacteria so widely distributed on the earth, the question arises as to their use or function in the world. We are accustomed to think of bacteria solely as the cause of disease, and off-hand we would say that this was their chief function. This is not true by any means, for instead of being harmful to life they are very beneficial; in fact, life could not be maintained without them. The causation of disease is a function limited to a small group of micro-organisms, and is of lesser importance. The much more important use of bacteria relates to their ability to produce substances called ferments or enzymes which bring about chemical reactions without entering into the reaction themselves. They can break down proteid substances (proteolytic enzymes), fat, and carbohydrates, into simpler chemical compounds and chemical elements.

The plants which form the food of animals would soon be exhausted unless they could obtain proper nutriment to sustain life and reproduce their kind. They live mainly upon carbon and nitrogen in the form of nitrates, which would soon be consumed from the soil unless the supply were continually replenished. Now, the source of carbon and nitrogen is the excretions and secretions of animals, which contain these elements in combination with other elements. By the action of bacteria the complex animal matter is decomposed into the chemical elements that compose it. In this way the plants derive their carbon and nitrogen from the soil. Within the body the bacteria carry on much the same activities. The digestion and absorp-

tion in the intestine is dependent to a large extent on the breaking down action of bacteria. We cannot absorb meat and vegetable as such, and it is only after our food has been separated into simple compounds and elements that it is absorbed to nourish the body. In this process the bacteria play no small part. But bacteria are not only agents capable of breaking down complex substances; they also build up substances from chemical elements. Some plants take their nitrogen from the air, but they would not be able to do so were it not for the presence of certain bacteria growing in the roots.

The maintenance of life in the world is often described as a cycle: first, the chemical elements are built up into plants, the plants nourish the animals, then the animal tissue is consumed and excreted to be broken down into elements. In each step the bacteria play a most important part.

Commercial Use of Bacteria.—These activities of bacteria and their enzymes are made use of commercially; the fermenting action on sugars converting them into alcohol is used in making beer and wine, the clotting of milk by bacteria in making cheese, the fermenting of cabbage in making sauerkraut.

PTOMAINES.

It may be well to mention here certain substances that are formed principally in the decomposition of meat and fish by bacteria. They are called ptomaines, and are present in partially decomposed animal and vegetable matter. Some of them are highly poisonous.

The most common poisonous ptomaines are those found in partially decomposed meat, fish, and ice-cream.

Questions in Review.

1. Why is it important to know the various properties of bacteria?

2. Of what value are dyes or stains in the study of bacteria?

3. Explain the uses of the various types of culture media?

4. What influence has environment on the growth of bacteria?

5. How can the knowledge of the distribution of bacteria be applied in a practical way to the care of the sick room and hospital ward?

6. Are the harmful or the harmless bacteria most numerous in the world? If it were possible, which would you destroy?

CHAPTER V.

THE DESTRUCTION OF BACTERIA AND ANTISEPTICS.

DISINFECTION, STERILIZATION AND ANTISEPSIS.

Definition.—The knowledge of the means by which bacteria are destroyed underlies the methods employed in disinfection, sterilization, and antisepsis as they are used in preventing the spread of infection. This branch of bacteriology has made rapid progress in recent years and has contributed much to the success of modern surgery, particularly in the treatment of infected wounds. The term *disinfection* means the total destruction of bacteria by any agent, while *sterilization* is limited to the destruction of bacteria by heat. An *antiseptic* is a chemical agent that prevents the growth and multiplication of bacteria, but does not necessarily destroy them. A *deodorant* is a substance that masks offensive odors or substitutes an agreeable odor for a disagreeable one. Some of the disinfectants and antiseptics are also deodorants, but few of the deodorants have disinfectant properties.

Destructive Physical Agents.

The agents that affect bacteria injuriously may be physical or chemical. Among the physical agents may be mentioned drying, light, and heat.

Drying.—Drying prevents the growth of bacteria and will eventually destroy them. The spores of bac-

teria, however, will resist drying for a much longer time. It is for this reason that the bacterial content of dust is chiefly in the form of spores. The effect of drying is influenced by the temperature at which the drying takes place, being much more injurious at high than at low temperature, also by the thickness of the material drying and the rapidity with which it is dried. Drying of bacterial smears on glass slides by intense heat over a Bunsen flame is much more destructive than drying in the air at room temperature.

Sunlight.—Sunlight is a very powerful and effective agent for destroying bacteria. By experiment it has been proven that the tubercle bacillus, the cause of consumption, is killed by sunlight in two hours or less, depending upon the thickness of the material surrounding it. The destructive action of sunlight is not due to the heat but to the ultra-violet rays of the sunlight. The effect of electric light and the X-ray is very much less powerful than sunlight, and to be effective must be concentrated and allowed to act for a greater length of time.

Heat.—Heat is the most powerful of all the physical agents. Its destructive action is dependent upon the degree of temperature and the length of time it is applied; the higher the temperature, the less the time required. It may be employed either as dry or moist heat. Burning in a flame is used for sterilization of platinum needles, cover glasses, and slides used in the laboratory. Dry heat is used in the sterilization of glassware, such as flasks, test-tubes, swabs and pipettes. The temperature should reach 140° to 150° C., and must be allowed to act for one hour in order to effect

sterilization. The instrument used for this purpose is called a dry-heat sterilizer, and consists of a double-walled box made of sheet iron and asbestos. An opening in the top admits a thermometer by which the temperature of the inner chamber may be measured. A tube with many Bunsen burners generates the heat

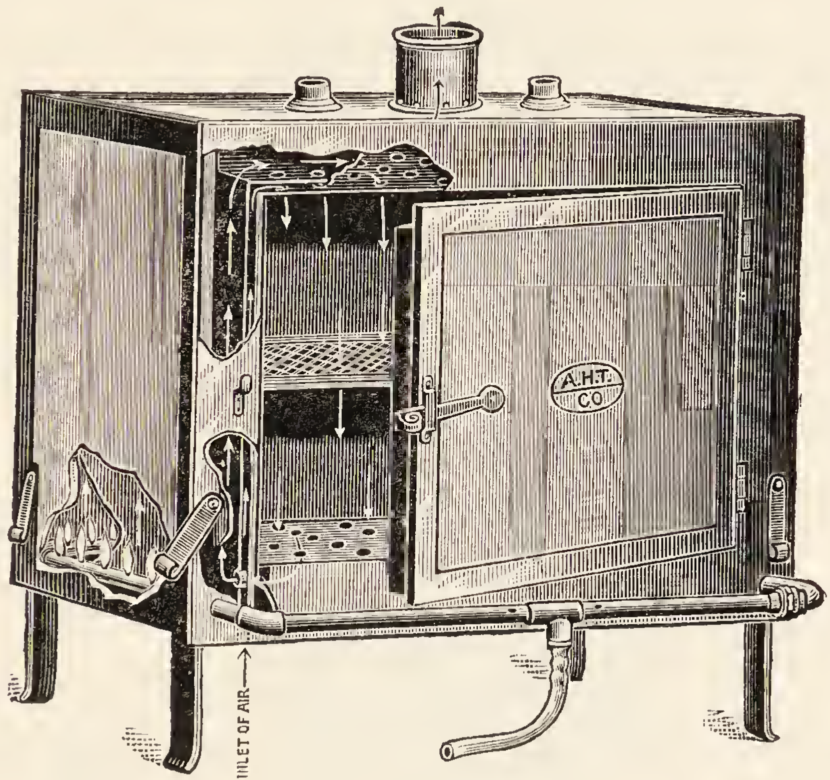


Fig. 10.—Dry heat sterilizer.

underneath, which circulates between the walls of the box, keeping the temperature even on all sides.

Pasteurization.—Pasteurization is a method of partial sterilization applied to milk. If milk is placed in a double boiler or water bath and heated to 60° C. for twenty minutes, 65° for fifteen minutes, or 70° for five minutes, tubercle and typhoid bacteria are killed, together with the organisms of diphtheria and scarlet fever and others.

Moist Heat.—For sterilizing all sorts of surgical instruments, except those with cutting edge, moist heat

is used. It is more effective than dry heat, because it has greater penetration. Boiling for five minutes will destroy bacteria but spores require longer boiling. Boiling for thirty minutes will destroy all forms of pathogenic bacteria and their spores. The destructive action is intensified and the danger of rusting avoided

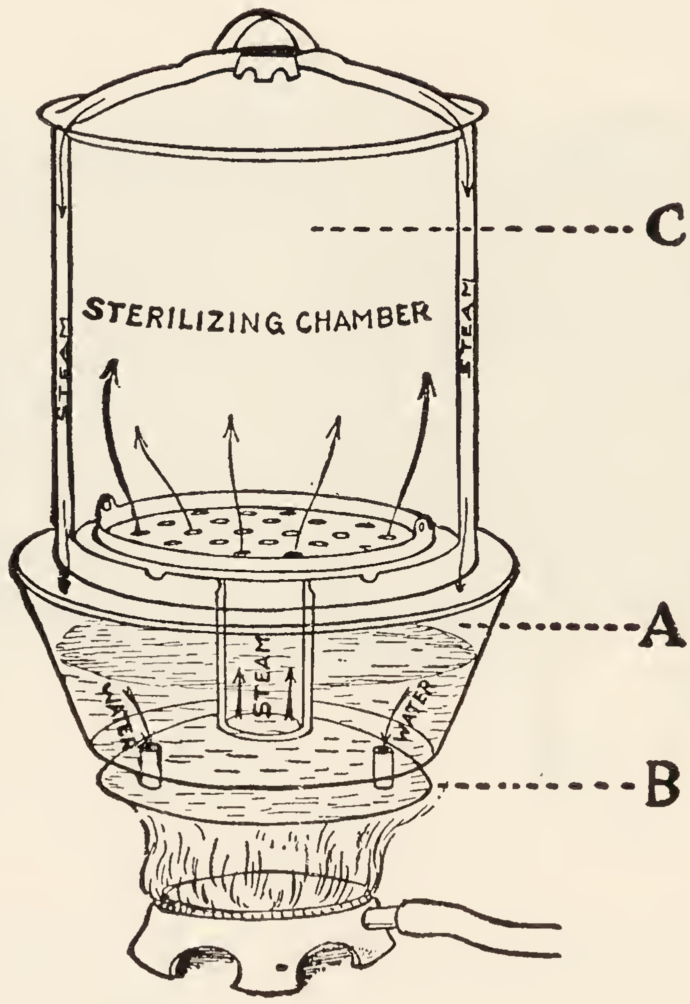


Fig. 11.—Arnold sterilizer. (Zinsser. D. Appleton & Co.)

if sodium carbonate is added to the water in amount sufficient to make a 1 per cent. solution.

Live Steam.—Live steam is employed for sterilizing dressings. The instrument most often used is the Arnold sterilizer (Fig. 11), which consists of two metal chambers (*A, C*), one within the other, beneath which is a pan (*B*) containing the water to be heated. A flame underneath boils the water and generates the steam,

which rises to the upper chamber (*C*) and penetrates the contents. The exposure of dressings in this way to live steam will kill pathogenic bacteria in thirty minutes but not their spores.

Fractional Sterilization.—Certain kinds of culture media, particularly those containing sugars, are sterilized by the Arnold method. In order to destroy the spores the media is exposed to the steam for thirty minutes on three successive days. After each exposure the media is exposed to room temperature to permit the spores to develop into bacteria. At the end of the third exposure it is presumed that all spores have developed into bacteria and all bacteria destroyed by the steam. Live steam is also used for killing bacteria in milk, and will be considered in detail in the Chapter on the Bacteriology of Milk.

Steam Under Pressure.—The most effective method of sterilizing by heat is the use of steam under pressure. The action of the steam is intensified and its penetrating power increased by the pressure. The instrument used is called an autoclave (Fig. 12). It consists of a double-walled cylinder or globe made of metal, with a steam gauge and vent at the top. The materials to be sterilized are placed in the inner chamber, the door closed, and the steam allowed to enter the outer jacket. The vent at the top is left open until all of the air has been forced out of the inner chamber. The vent is now closed and steam is allowed to enter the inner chamber until the gauge registers a pressure of fifteen pounds, or one atmosphere (corresponding to a temperature of 121.3° C.), and allowed to remain so for twenty to thirty minutes. This exposure will kill all

bacteria and spores (Fig. 13). If any fluid contained in flasks or test-tubes is being sterilized, care must be taken that the steam be allowed to escape gradually at the end of the exposure, otherwise the suction will draw the plugs from them. Much larger sterilizers which embody the same principles as the one just described

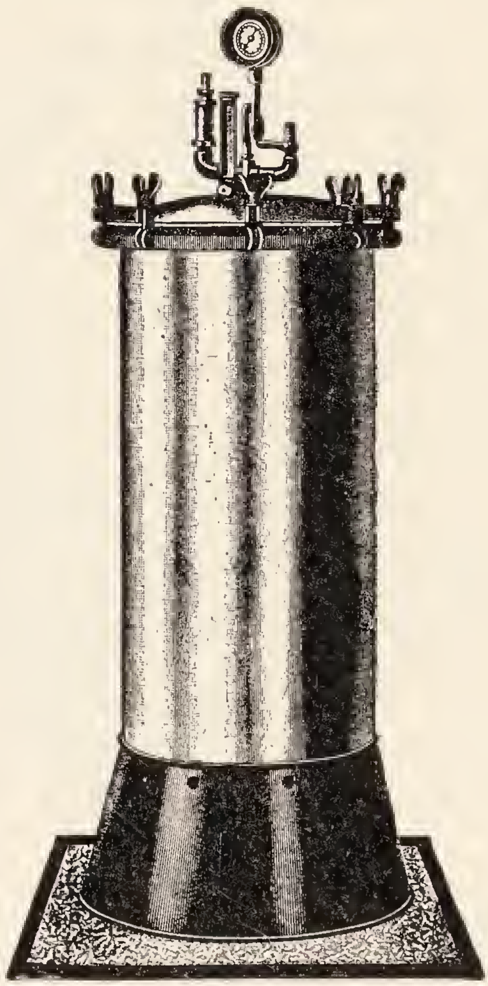


Fig. 12.—Autoclave. Upright type.

are used by hospitals, quarantine stations, and departments of health in cities for disinfecting wearing apparel, bed-clothing and bedding.

Chemical Disinfectants.

The number of chemical agents having destructive action on bacteria is very large. It will suffice to mention a few of the common ones, and describe the

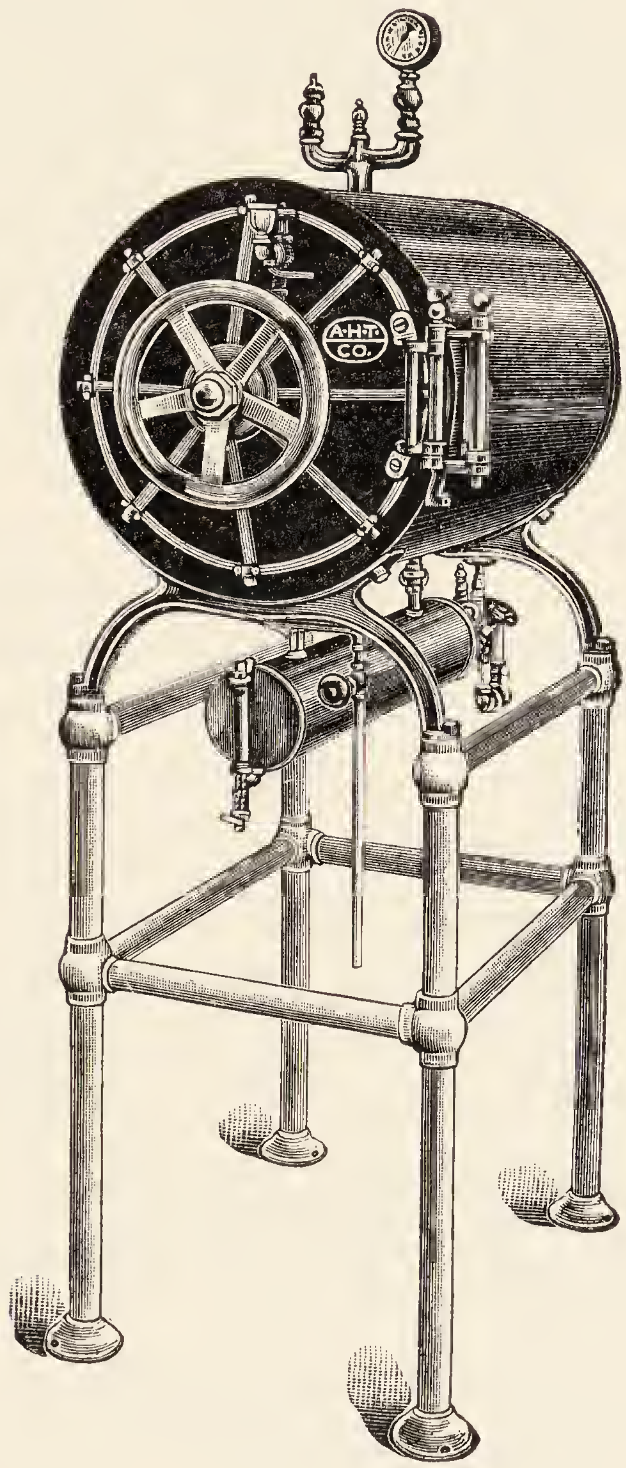


Fig. 13.—Autoclave. Horizontal or hospital type.

way they may be applied best. Chemical disinfectants may be used dry, in solution, or in the form of gas.

Dry Disinfection.—As examples of dry disinfectants, boric acid, bismuth and iodoform may be mentioned. All are used in concentrated form as they are obtained commercially. Boric acid and bismuth are weakly bactericidal, and have an antiseptic rather than a disinfectant action. Iodoform when iodine is set free is disinfectant. Their chief use is on infected wounds.

Solutions.—Some of the most used disinfectant solutions are as follows:

Formalin	10–20 %
Bichloride of mercury	1 : 500–1 : 1000.
Carbolic acid	5%.
Chlorinated lime	5%.
Dakin's solution	1–4%.
Hydrogen peroxide	20%.
Alcohol	70%.
Mercurochrome	2%.
Acriflavine	1–1000.
Hexylresorcinol	30–50%.

Not all of these solutions are equally efficacious for disinfecting and each one has its advantages and disadvantages.

Formalin is an excellent disinfectant, and, in addition, is also a good deodorant. It does not injure fabrics, is not poisonous, and does not coagulate albumin. It is liable to rust iron and steel. It is suitable for the disinfection of urine, sputum, feces and albuminous discharges. It is not a good skin disinfectant because it hardens the skin and in some cases will cause a dermatitis.

Bichloride of mercury is of limited usefulness because it is a corrosive poison, corrodes all metals, and coagulates albumin. This last action renders it of little use for the disinfection of sputum, feces or pus. On the other hand, it is excellent for disinfecting floors, walls and furniture; that is, surface disinfection. In the strength of 1: 1000 it kills bacteria in a half an hour, but for spores a 1: 500 solution must be used. It is widely used for skin disinfection; for this purpose a 1: 1000 solution is sufficiently strong. On account of the poisonous property of bichloride solutions it is safer to add coloring material to prevent any possibility of their being drunk by mistake.

Carbolic acid is suitable for the disinfection of intestinal discharges, sputum, urine, floors, furniture, soiled linen and clothing. It will coagulate albumin, but its action is not interfered with to so great an extent as is the case with bichloride of mercury. Carbolic acid comes in the form of colorless crystals. If a solution is desired 10 per cent. of water must be added. Its disinfecting power is increased by the addition of salt. Cresols, chemical substances closely related to carbolic acid, are more powerful and not so poisonous. They may be used in 5 per cent. solution. Lysol and creolin are solutions of cresol with potassium soap. Carbolic acid is used in 5 per cent. solution usually. Lysol and creolin are used a great deal for douches and usually in 1 per cent. strength.

Chlorinated lime is a deodorant as well as a disinfectant, both properties being dependent upon the liberation of chlorine gas in the presence of moisture. It is most widely known and used for the disinfection of

intestinal discharges of typhoid fever patients. It undergoes decomposition readily; so care must be taken that it be fresh if good results are expected. For disinfecting stools the amount of lime solution should be much in excess of the amount of the stool, and it should be allowed to act for several hours. It can also be used for disinfecting floors and woodwork, but should not be used on colored fabrics, as it is a powerful bleacher.

Dakin's solution is a neutral solution of sodium hypochlorite. It is used in strengths varying from 1 to 4 per cent. During the war it was used a great deal for the disinfection of wounds either in the form of wet dressings or by irrigation. The solution decomposes readily, so care must be used that the solution is fresh and kept in well-stoppered bottles. Chloramine-T is a more stable form of hypochlorite solution and is generally used in 2 per cent. solution in the treatment of wounds. Dichloramine-T is another chlorine disinfectant but is insoluble in water. It is dissolved in oil or paraffin and is sprayed on wounds or gauze covering wounds in from 6 to 10 per cent. strength.

Hydrogen peroxide decomposes readily, giving off free oxygen upon which its disinfectant action depends. It is used to a large extent for destroying the pus bacteria of superficial wounds, and is an excellent mouth disinfectant.

Alcohol, either absolute or in 95 per cent. strength, is weakly disinfectant. The addition of water seems to add to its disinfecting action. Solutions of 50 to 70 per cent. are the best. The use of alcohol is limited. Perhaps the greatest usefulness is in destroying bac-

teria in the skin, although even for this it is rarely depended upon alone.

Acriflavine and Other Dyes.—A number of dyes have disinfectant properties. Acriflavine is a yellowish dye, usually used in a strength of 1 : 1000 in salt solution. It was originally recommended for use in destroying trypanosomes but is now used in treating infected wounds. It can be used locally in the mouth or in the urethra and bladder.

Gentian violet, malachite green, and brilliant green are disinfectant particularly for the Gram-positive bacteria such as the pus cocci. For this reason solutions of these dyes are used for dressing infected wounds. They retard the healing of wounds, however.

Mercurochrome is used a great deal at the present time. It is a combination of a mercurial salt with a dye. It has deep penetration and is not irritating. It is used in 1 per cent. or 2 per cent. solution. Many surgeons use it as a skin disinfectant preceding an operation. It has an intense red color; on fabrics it leaves a stain that is very difficult to remove.

Gases.—Of the disinfectant gases only the two most often used need be mentioned: *Sulphur-dioxide gas* is made by burning roll sulphur in the presence of water vapor. The vapor is essential because the disinfectant action depends upon the formation of sulphurous acid, which is made by the combination of the water vapor with the fumes of sulphur. It requires about eight pounds of sulphur for every 3000 cubic feet of air space, and should be allowed to act for at least twenty-four hours. It is a surface disinfectant, having very little penetrating power, and is not as reliable as it was

once thought to be. It is better than formaldehyde for killing insects like fleas, bed-bugs, and lice which often are carriers of infectious disease. It is liable to corrode fabrics and destroy colors. It tarnishes metals and leaves a disagreeable odor for some time after it is used.

Formaldehyde gas is made in a variety of ways. For use in hospitals and by boards of health an autoclave is used, which generates the gas under pressure. After the room has been sealed to prevent the gas from escaping, the gas from the autoclave is forced into the room through the keyhole of the door. The room should be kept sealed for twelve hours after the gas is used. A much simpler way that is practical for home disinfection is the burning of paraform candles in the presence of moisture. The disinfectant action is strongest when the temperature of the room is between 90° and 100° F. The gas is a surface disinfectant; consequently, articles to be disinfected should be hung up or so arranged as to allow the free circulation of the gas about them. It is the most efficient disinfectant known when properly used, and is also a deodorant. It has no harmful action on clothing or other household goods. The vapor is very irritating to the eyes and upper air-passages. Although the gas is very destructive to bacteria and their spores, it will not kill vermin.

Disinfection of Excretions.

In disinfecting during or after illness of contagious or infectious nature, it is necessary to render all discharges, excreta, and so on, non-infectious and, at the conclusion of the illness, to render the apartment in

which the patient has been sick safe for others to occupy. During sickness with an infectious disease it is necessary for attendants to avoid carrying the infection to others and to see to the disinfection of clothing, eating utensils, and so forth, that have been used by the patient. The nurse in attendance should be careful to disinfect the hands after handling the patient. The hands should be soaked in a 2½ per cent. solution of carbolic acid or 1 : 1000 corrosive sublimate solution, then washed in soap and water. The nails must be kept clean. When leaving the room the same precaution should be taken. A gown should be worn over the uniform and hung up with the outside turned in when not in use in the sick room. Dishes, knives, forks, and spoons used by the patient should be marked and kept for his exclusive use. After being used they should be immersed in carbolic acid solution, then washed in hot water with soap. Any food not consumed by the patient should be burned up. Hand basins used by the nurse or patients, slop sinks, and toilet bowls must be kept scrupulously clean and disinfected with carbolic acid solution. Do not use bichloride solutions here as the corrosive action is bad for the plumbing. In practical disinfection the choice of the disinfectant should be governed by the source and character of the material to be disinfected, and by the expense, the ease, and the thoroughness with which the disinfectant may be applied.

Sputum.—Sputum always contains a large proportion of mucus, in which the bacteria are imbedded. In order to destroy these bacteria, chemical agents of considerable penetrating power are required, and should

be allowed to act for considerable periods of time. The two that best meet these requiremens are formalin, 10 per cent. solution, and carbolic acid in 5 per cent. strength. A much safer way is to collect all sputum in paper sputum cups or paper napkins and burn them. This way has been in use a long time for the disposal of tuberculous sputum, but it is equally as practical for the mouth and nasal discharges of diphtheria, tonsillitis, pneumonia, and cerebrospinal meningitis.

Feces.—Feces can be quickly and thoroughly destroyed by burning them or mixing them with boiling water. If chemical disinfectants are employed formalin (10 per cent.) or carbolic acid (5 per cent.) may be used. The amount of either of these solutions should be twice that of the stool. Chlorinated lime, so long used for stool disinfection, has no advantages over formalin or carbolic acid, and is not so easy to use. The urine may be disinfected in the same manner as the stools.

Clothing.—Clothing, towels, napkins and bedding should be soaked for one-half hour in a 5 per cent. solution of carbolic acid before leaving the sick room to be laundered.

Apartments.—Apartments occupied by persons sick with contagious disease should not be occupied again until the room and its contents have been thoroughly disinfected. In order to simplify this procedure a little forethought on the part of the nurse, in removing from the sickroom all articles not to be used, will assist a great deal. Carpets, upholstered furniture, hangings, pictures, and bric-a-brac can easily be spared from the room. At the conclusion of the illness by far the most

effective means of rendering the room free from infection is a thorough scrubbing of everything washable with soap and hot water, a continued exposure of the room to fresh air and sunlight, and the burning of everything that cannot be washed or is of small value. The effect of the scrubbing is increased if followed by a solution of carbolic acid or bichloride solution. If arrangements cannot be made to have the mattress sterilized by steam under pressure it is safer to burn it.

If the disinfection of the apartments by gas, either formaldehyde or sulphur, is to be employed, it should follow the cleansing of the room after the manner described above. The room must first of all be sealed to prevent the gas from escaping. This can be done by plugging with cotton all crevices about the windows and doors, and pasting paper over radiators and ventilators.

Not much dependence should be placed on gas disinfection alone. It should be clearly understood that a thorough application of soap and water and free exposure to fresh air and sunlight are much to be preferred to the simple introduction of formalin gas or any other disinfectant without due regard to the proper disposition of the room contents, temperature, time of exposure, and the quantity of the disinfectant used. The careless use of gas disinfection and the popular belief that filling a room with gas kills all contagion have led to disastrous consequences, and are responsible for the disrepute into which disinfection has fallen in some quarters.

Questions in Review.

1. Define: Disinfection, sterilization, antisepsis, asepsis, deodorant?

2. Are physical agents or chemical agents of the greater importance in the destruction of bacteria?*

3. What is the practical use of fractional sterilization?

4. Name some chemical disinfectants not mentioned in the text and give the strength in which they should be used?

5. How much sulphur would be required to disinfect a ward 60 x 40 x 10 feet, if it requires 8 pounds for every 3000 cubic feet?

6. How should a nurse prepare a room in a private house to be occupied by a patient with contagious disease?

7. What should be done afterward to make the room safe to be re-occupied?

* This topic might be used as a subject for a 5-minute debate.

CHAPTER VI.

INFECTION.

PATHOGENIC AND NON-PATHOGENIC BACTERIA.

In the preceding chapters we have been dealing with the subject of bacteriology in the broadest sense. Attention has been directed to the function of bacteria in the life of the world, to their appearance, their manner of growth, and the means employed for their destruction. As physicians and nurses our interest centers about a very small part of the bacterial kingdom, the one having to do with the production of disease. Bacteria that produce disease are termed *pathogenic,* while those varieties that do not are called *non-pathogenic.* By far the larger number of pathogenic bacteria thrive only in the living tissues of animals. These are called *parasites.* Some kinds of bacteria thrive only on dead tissues or wounded surfaces and, by decomposing them, form poisons (ptomaines) which may be absorbed and give rise to symptoms such as fever, chills, and headache. These are termed *saprophytes.* When pathogenic bacteria gain access to the tissues and produce injury and symptoms, we say that infection has taken place.

INFECTION AND CONTAGION DEFINED.

Here it may be well to say a word as to the meaning of the terms "infectious" and "contagious." They have been used somewhat loosely and have led to a great deal of confusion. Any disease that is caused by the

entrance into the body of a living micro-organism capable of producing injury to the tissues is *infectious*. As examples of infectious disease, diphtheria, pneumonia, influenza, tuberculosis and syphilis may be mentioned; although there are many others. A *contagious* disease is one that may be transmitted directly from one person to another. Contagious diseases are less often transmitted by such objects as insects, eating utensils, bedding, etc. Smallpox, scarlet fever, measles, chickenpox, and German measles are usually classed as contagious diseases. All contagious diseases are infectious, but not all infectious diseases are contagious. Diseases like cholera, glanders, pneumonia, plague, tuberculosis, and syphilis cannot be transmitted through the air or by coming into the presence of the sick. Typhoid fever may be considered infectious through water and other infected foods, and contagious by contact with the so-called typhoid carriers.

The terms "infestation" or "infestion" are applied to diseases caused by entrance into the body of small parasites such as amebæ, worms, and so on.

FACTORS INFLUENCING INFECTION.

While the presence of pathogenic bacteria is necessary to cause infection, other factors of much importance must be taken into consideration. This must be so, as everyday experience shows. In any epidemic of infectious disease only a portion of those exposed become infected. Even among those infected the disease presents all variations from the very mild to the most severe. The factors that influence the onset and

course of infections relate both to the bacteria and the individuals exposed to them.

On the Part of Bacteria.

Virulence and Attenuation.—So far as the bacteria themselves are concerned, infection depends in part on their power of producing disease, that is, their virulence. Conditions that are not suited to the growth of bacteria will diminish or destroy the virulence; the continued cultivation of bacteria outside the body on artificial culture media will do this. Bacteria that have lost the power of producing disease are spoken of as being attenuated.

Number.—Another factor that modifies infection is the number of bacteria that invade the tissues. While the exact number of bacteria necessary to cause infection is not known, it may be said that the greater the virulence the fewer the bacteria required.

On the Part of the Individual.

Concerning the individual exposed to infection it is known that everyone is endowed to a variable degree with defensive substances in the blood and tissues that tend to overcome and destroy invading bacteria. Unhealthy people, as everyone knows, are more likely to become infected and to succumb to infection than the healthy. We are protected by the skin to a great degree. The passage of pathogenic bacteria through the skin is possible but does not often take place. We are further protected by the secretions of the mouth and gastro-intestinal tract. The acid secretions of the stomach exert a harmful and destructive action on many

bacteria. The blood and tissues of the body offer much resistance to invading micro-organisms under normal conditions of health. If the health is impaired by disease this resistance is lowered and infection is more likely to occur. This power of the human organism to resist infection will be discussed more fully under the subject of immunity.

AVENUE OF INFECTION.

The path by which bacteria enter the tissues frequently determines whether infection is caused or not. The bacilli of typhoid fever to cause infection must be swallowed, but if they are rubbed into the skin no infection results. On the other hand, the pus-forming bacteria like the staphylococci and streptococci may be swallowed without causing infection, but if they are rubbed into the skin a boil or an abscess is almost sure to result. So to cause infection bacteria must enter the body through channels best adapted to their growth and multiplication.

Infection From Bacteria Outside the Body.

How does infection take place? It is the result of the invasion of the body tissues by pathogenic bacteria that live either on the surface of the body or from those that live on the mucous membrane inside the body. Injuries play an important part in causing infections. Injuries caused by firearms may be the entering point of tetanus bacilli, the cause of lockjaw, while rabies or hydrophobia is spread through the bites of mad dogs. Careless manipulations with soiled catheters, speculums, syringes, and so on, may cause injury to the tissues and

be the means of introducing bacteria. In the case of the contagious fevers like measles, chicken-pox, whooping-cough, and scarlet fever the infecting agent is expelled into the air by coughing and sneezing and causes infection by being inhaled. Bedding, clothing and utensils that have been contaminated with infectious material may be the means of spreading infection. It is known that certain kinds of mosquitoes transmit malarial fever and yellow fever, flies may spread typhoid fever by depositing the typhoid bacilli on food materials.

Carriers.—Infection may be caused by carriers, that is, individuals who harbor infectious bacteria in their bodies, which may not produce any disease in them but may cause infection in others with whom they may come in contact. Such persons are called contact carriers. A certain number of people that have recovered from infectious disease continue to harbor the infectious bacteria for long periods afterward. They are termed convalescent carriers. The length of time a person may be a carrier is of course variable but in the case of typhoid carriers the condition may persist for years and generally the infection is located in the gall-bladder and excreted into the intestine and feces. A number of other diseases may be disseminated by carriers, among them, diphtheria, dysentery, influenza, meningitis, pneumonia, scarlet fever, and amebic dysentery.

Infection From Bacteria Living Inside the Body.

The body may be looked upon as the host for large numbers of bacteria. At birth, however, all healthy animals are free from bacteria; but almost immediately

afterward they are deposited upon the surface of the body by the dust in the air, and are introduced into the body by food and the air breathed. When these bacteria gain access to the body, only those survive that find the conditions favorable for their existence. For this reason it is found that each cavity or portion of the body harbors a group of bacteria peculiar to it. The varieties of bacteria found in the saliva, for example, are quite different from those found in the intestine. Most of these constant bacteria of the body are harmless, but some pathogenic forms occur which manifest their power to produce disease only when some injury affords a point of entrance to the tissues or the resistance of the individual is lowered.

In the Skin.—There may be in the skin many kinds of bacteria, the most important of which are the pus-forming cocci, the staphylococci, and streptococci. They do no harm under normal conditions, but if there is any injury to the skin these organisms may enter and give rise to a boil or an abscess. It is mainly against these pus-forming bacteria that the preparation of the patient before operation is directed. Unfortunately these bacteria live actually in the skin, that is, below the surface; so that skin disinfection must be very thorough to be effectual and, even under most favorable conditions, cannot be considered as absolute.

Air Passages.—In the air passages large numbers of bacteria are found which enter with the air breathed in. Most of them are caught on the moist surfaces of the mouth, throat and nose; very few if any ever reach the lungs directly through the trachea and bronchi. In the mouth the pneumococci, staphylococci, and strep-

tococci are frequently present, but do no harm unless the vitality is lowered.

Stomach and Intestines.—The stomach is generally free from bacteria, due to the acid in its secretions. If, however, there is any disturbance of digestion and the secretions are no longer acid, the bacteria swallowed in the food may cause fermentation and other disorders. The intestine harbors great numbers of bacteria, chiefly the colon bacillus and others closely allied to it. They are, in health, not only harmless, but of much benefit in breaking down the food into substances that can be absorbed for nutriment of the tissues. Under conditions of lowered resistance or when injury to the intestines has been done, they may cause infection.

Local or General Infection.

After infection has taken place it may remain localized in the form of a boil or abscess, or it may spread so that the blood contains the infecting organism. When infections become generalized the condition is called septicemia, and when there is added to this scattered areas of pus formation throughout the body the condition is called pyemia. Focal infection is one that is localized at one point and from this point is disseminated to other locations. The infected tonsil or abscessed tooth producing an endocarditis is a common example. The bacteria causing these infections are carried in the blood stream to distant organs. In their new location they may set up another point of infection sometimes much more serious than the original one. Toxemia is the condition caused by the poisons of bacteria, either in local or general infections.

INJURIOUS ACTION OF BACTERIA.

How do bacteria produce injury to the tissues? In two ways: The multiplication of bacteria in the tissues may cause injury in a mechanical way acting as a foreign body and setting up an inflammation. The resultant swelling of the tissues causes pressure on the blood capillaries followed by obstruction. At times the bacteria may be carried in the blood stream into tiny capillaries and obstruct them. This is spoken of as bacterial embolism. The tissue supplied by such capillaries being deprived of blood supply undergoes necrosis. The absorption of the necrotic material gives rise to the symptoms of infection.

Toxins, Extra- and Intra- Cellular.—Much greater injury is produced by the absorption of the poisons or toxins made by the bacteria. These poisons may be extracellular or intracellular. The extracellular toxins are thrown out of the bodies of the bacteria into the tissues or media in which they are growing. The word toxin when used alone is taken to mean an extracellular toxin. The intracellular or endotoxins are retained within the bodies of the bacteria and are set free only after their death or dissolution. After absorption the bacterial toxins do not affect all organs or tissues equally, but exhibit a selective action, some attacking the red blood-corpuscles and dissolving them, others the tissues of the brain and nervous system.

Questions in Review.

1. Define: Infection, contagion, focal infection, septicemia and pyemia.

2. Why are not all infections general infections?

3. Define: Pathogenic, parasite, and saprophyte.

4. What factors govern the severity of an infection?

5. What makes an infected person sick?

CHAPTER VII.

IMMUNITY AND IMMUNITY REACTIONS.

From what has been said in the previous chapter one might think that men and animals are wholly at the mercy of bacteria. Fortunately this is not so, as all are endowed with certain defensive powers that resist the injurious action of bacteria and their poisons.

IMMUNITY.

Natural Immunity.—This resistance to disease is called *immunity,* while the lack of resistance is called *susceptibility.* Nature supplies us with a resistance to certain diseases. This is called natural immunity. A number of diseases that affect man do not occur in animals. Leprosy is such a disease, while chicken cholera does not affect human beings. This type of immunity may be due to some extent to differences in diet, the carnivorous animals being resistant to diseases to which herbivorous animals are susceptible.

Racial.—Some races in which infectious disease has existed through many generations gradually develop a resistance or immunity to those diseases. For example, the negro seems to possess a much greater resistance to yellow fever than the white man, due to the fact that yellow fever has been prevalent among the negroes of the tropical countries for many years. On the other hand, a new kind of infection to which a race of people is not accustomed usually proves very virulent, as

shown in the susceptibility of the negroes and American Indians to tuberculosis.

Individual.—In addition to the variations in resistance among the races of man there are also variations among individuals. The conditions under which people live have much to do with their resistance. Unsanitary homes and work-shops, fatigue, exposure, poor nourishment, and injuries all tend to lower the resistance to disease. The excessive or continued use of alcohol is a very important factor in lowering resistance, as is shown by the frequency of infectious disease, particularly pneumonia and tuberculosis, among drinkers. Constitutional diseases, like diabetes and nephritis, also lower the resistance as the great frequency of infections that occur in diabetics shows.

Acquired Immunity.—It is possible to acquire immunity. Following an attack of infectious disease there commonly results an immunity that protects the individual from a second attack. The resistance gained in this way is spoken of as acquired immunity and follows diseases such as measles, mumps, scarlet fever and typhoid fever. The duration of acquired immunity varies; after scarlet fever it oftentimes lasts during life, while after typhoid fever it may last only a year or two. That immunity could be acquired in this way was known many years ago, and led to the conception of producing immunity artificially without actually causing the individual to pass through the dangers of disease. Although not the first to attempt to produce immunity artificially, the experiments of Jenner, who discovered the protective effect of vaccination, were the most successful. The events leading up to Jenner's discovery

are interesting. In England, where smallpox had been a scourge for many years, it was observed that people who had been accidentally infected with cow-pox, a modified form of smallpox in cattle, were not attacked by smallpox even though they were exposed to it. Jenner reasoned that if an accidental infection with cow-pox could prevent against smallpox it would be a rational procedure to purposely infect with cow-pox. So, acting on the advice of his patron, Dr. John Hunter of London, he inoculated a boy with pus from a cow-pox pustule in May, 1796, and two months later injected the pus from a smallpox pustule without producing any disease.

Active Immunity.—When immunity is acquired by introducing into the body the infectious agents in modified form or in small amount, it is spoken of as active immunity because the body tissues take an active part in forming the substances that give protection. Our knowledge of how immunity is produced in this way is due principally to Pasteur who found that bacteria, which had become less virulent or attenuated in one way or another, could no longer cause serious infection but still could develop an immunity in the one inoculated. He found that the bacteria producing chicken cholera became much less virulent after being cultivated for long periods of time on artificial culture media, or after cultivation at increased temperatures.

Attenuation of bacteria may be brought about in other ways: By growing them in culture media containing weak antiseptics, or by heating cultures for short periods. Active immunization has been attempted in the case of mildly virulent infections by the inocula-

tion of the living bacteria in very small amount. This method of immunization has no wide application.

Vaccines.—The introduction of dead bacteria or vaccines in increasing doses is often used to develop immunity against those bacteria whose poisons are intracellular. This method has been practised a great deal these last few years, and has been attended with considerable success in some infections. Its most successful application has been in the preventive inoculation against typhoid fever in the army. Finally, active immunity may be produced by using the toxins of living bacteria. These toxins are extracellular and develop in the fluid culture medium used. The living micro-organisms may be removed by passing the fluid through a Berkefeld porcelain filter, leaving the fluid containing the toxin free from bacteria. If slowly increasing doses of this toxin are given to animals they will slowly develop an immunity. Immunization by this method is used against diphtheria and tetanus (lock-jaw) in animals. Active immunity developed by these methods is used largely in the prevention of infection. Because of the time required for the immunity to develop it is not applicable to the cure of infection after it has begun, except in a few infections, or when the incubation period is long, as in rabies.

Passive Immunity.—There is another type of immunity that can be conferred without the body tissues taking any active part in the process. For this reason it is called passive immunity. In 1890 von Behring discovered that the blood-serum of animals that had been immunized to the poisons of diphtheria and tetanus, if injected into other animals, would protect them also.

Later Dr. Flexner, at the Rockefeller Institute in New York, made similar observations in connection with the poison of the meningococcus, the organism causing the epidemic form of cerebrospinal meningitis.

Method of Obtaining Antitoxin.—Perhaps a brief description of the way diphtheria antitoxin is made will make this type of immunity better understood. The animal used in the commercial preparation of diphtheria antitoxin is the horse. At the start the animal is inoculated with a very small dose of the diphtheria toxin obtained by growing the diphtheria bacillus on large flasks of bouillon. The bacilli are filtered out and the filtrate containing the soluble diphtheria toxin is used for injecting. The effect of the first injection is to make the horse sick, but not fatally so. At the end of a week a second injection is made with the same dose, but the animal is now able to stand the poison without ill effect, due to the protective substances formed in its body. In other words, active immunity has been established in the horse. At the end of three or four months the animal is bled to the amount of five or six quarts, and the blood is set aside to clot. In the serum that separates from the clot are the same substances that protected the horse from the diphtheria poison. This is the diphtheria antitoxin. It is standardized by determining the smallest amount of antitoxin that will neutralize one hundred times the fatal dose of toxin for a guinea-pig weighing 250 grams. This amount is called the antitoxin unit, and enables us to measure the dose of antitoxin.

Use of Convalescent Serum.—The use of blood serum taken from people who are convalescent from such in-

fections as measles and anterior poliomyelitis (infantile paralysis) has been practised to some extent quite recently. The serum of such convalescents contains antitoxins for these infections. The results obtained by this procedure have not been as successful as could be wished. There are certain precautions that must be observed, too, which will be described more in detail in the chapters dealing with hypersusceptibility.

Passive immunity, while it has and still does, save the lives of great numbers of people, is transient. It passes off in about three weeks leaving one again susceptible to the same infection. Active immunity, on the other hand, is of much longer duration and frequently lasts for years.

HOW THE BODY RESISTS INFECTION.

Phagocytosis.—What the nature of these substances is that enables us to resist infection is not known, and the way in which they act is built up on theory that is complicated and difficult to understand. It is sufficient to know that soon after infection occurs the body tissues and fluids begin to protect themselves against the invading bacteria and their poisons. The first defense is made by certain tissue cells of the body known as phagocytes. These are the white cells of the circulating blood or leucocytes, the endothelial cells, which form the lining of serous cavities, like the pleural and peritoneal cavities, and giant cells, the origin of which is not known. Phagocytes destroy foreign substances, living or dead, by taking them into their bodies, killing them and digesting them. Bacteria, when introduced into tissue attract the phagocytes in large numbers.

This is not true of all bacteria for some seem to repel rather than attract leucocytes. This is the case with the bacillus of tuberculosis.

In many acute infections the increase in the number of the leucocytes in the circulating blood gives an index of the severity of the infection. For this reason the leucocytes are counted. The blood is collected in a pipette and diluted 1 : 200 with a dilute solution of acetic

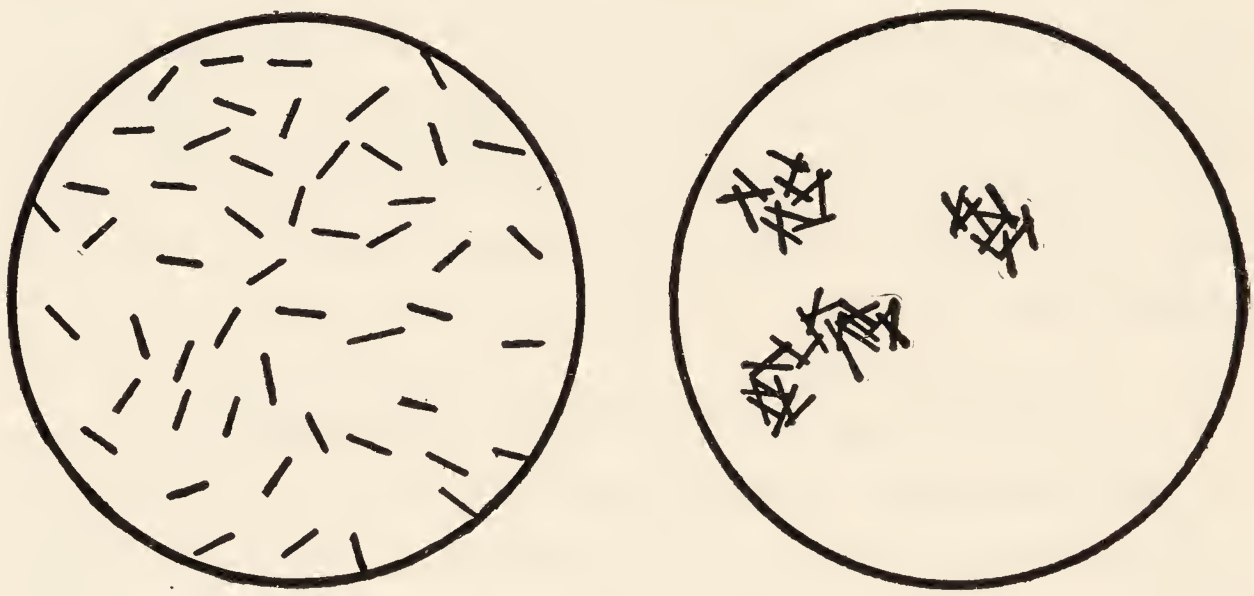


Fig. 14.—Microscopic agglutination reaction.
(Zinsser. D. Appleton & Co.)

acid which destroys the red blood cells and leaves the leucocytes. The number of leucocytes in a cubic millimeter is counted on a ruled glass slide. The normal number of leucocytes is 7000 to 10,000 per cubic millimeter. If the number exceeds this there is a leucocytosis indicating an acute infection. Typhoid and similar infections are exceptions. Here there are generally fewer leucocytes than usual in the blood, or a leucopenia. This is characteristic of the typhoid group of infections. The fate of infections depends many times on the defense of the phagocytes; if they are sufficient

for the needs of the occasion the infection is checked and localized; if they are not, the infection extends and may become general.

Antibodies.—The body, however, does not rely entirely on the phagocytes for protection. Infection stimulates the tissues to form substances, circulating in the blood serum, which combine with and neutralize the poisons of bacteria. They are spoken of as *antibodies* and operate in different ways; some called *bacteriolysins* cause the bacterial cells to swell, become granular, and eventually to dissolve. *Agglutinins* gather bacteria in clusters or clumps and render them inert (Fig. 14). *Precipitins* are present in the blood serum and cause a precipitate to form in extracts of bacteria. Finally, substances may be formed that act on the infecting bacteria in such a way as to make them more readily destroyed by the phagocytes; these are called *opsonins*.

Reactions of Immunity.

These antibodies are specific. This means that the antibodies of a person immune to typhoid fever will exhibit these reactions only with the bacterium to which they are immune. The agglutinins in the blood of a person immune to typhoid fever will act only with the typhoid bacillus, the bacteriolysins of cholera immunes will dissolve only the cholera spirillum and so on.

These reactions of immunity as they are called, because they are specific, are used in the identification of unknown bacteria. For example, the blood serum of a person known to be immune to typhoid infection, if mixed with a culture of an unknown bacillus, will agglutinate it, if it is the typhoid bacillus.

It is an interesting fact, and one of much importance, that the amount of these protective substances formed is not only sufficient to render an infection harmless, but is greatly in excess of the needs of the moment. They remain stored away in the cells ready to be utilized when the same infective agent again attacks; this is the way that immunity is established.

Questions in Review.

1. Define: Antibody, agglutinin, precipitin, opsonin and bacteriolysin.

2. What is the difference between active and passive immunity? What is natural immunity? What is acquired immunity?

3. What great discovery was made by Edward Jenner?

4. What are antitoxins and describe how diphtheria antitoxin is made?

5. What defense does the body make against infection?

6. What is meant by saying that the reactions of immunity are specific?

7. Why is it that one attack of certain infectious diseases protects us all our lives?

8. How are the reactions of immunity used in the identification of bacteria?

CHAPTER VIII.

COMPLEMENT FIXATION, ALLERGY AND ANAPHYLAXIS.

COMPLEMENT FIXATION.

It has long been known that the blood serum of normal individuals contains substances that destroy bacteria to a variable degree. In individuals made immune to disease this bactericidal power of the blood serum is greatly increased. It developed from experiments made by Bordet that this destructive effect of the blood serum could be reproduced in animals immunized to the red blood corpuscles of other animals. For example, if a rabbit be immunized gradually to the red blood cells of man, the rabbit's blood serum will dissolve or hemolyse the human red blood cells when mixed with them in the proper proportions. It is not, however, one single substance in the rabbit's serum that produces this effect but two substances, one of which is always present in the blood serum, the other only after immunization has occurred. This latter substance will act only with the substance to which the serum is immune and for this reason is said to be specific. These three substances taking part in the solution or hemolysis of the red blood cells are designated: antigen, complement, and amboceptor.

In the example given above the antigen is the human red blood cell, the complement is the substance always present in the blood serum, and the amboceptor

is the substance present in the blood serum of the rabbit after immunization.

The term antigen is applied to any substance which, when injected into a living animal, causes the formation of antibodies, viz., red blood cells, bacteria or bacterial poisons. The immune substance produced by the injection of the antigen is called the amboceptor. It differs from the complement that is present in all serum, by the fact that it is not so sensitive to heat and so is said to be thermostabile.

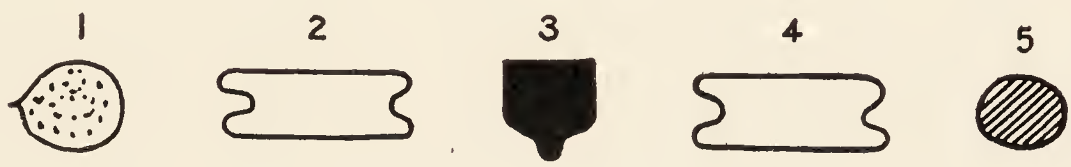
In the experiment just described with the human red cells and the rabbit's serum immunized to them, it is possible to add just enough corpuscles to use up or fix all the complement.

Similar experiments may be made with a number of antigens, such as the gonococcus, the *Treponema pallidum,* the typhoid bacillus, the glanders bacillus and others. This principle of mixing antigen, complement, and amboceptor in definite proportions so that the complement is fixed is the basis of complement fixation as applied in the diagnosis of disease.

The Wassermann Test.—Perhaps the one most used is the Wassermann test for syphilis. The object of the test is to determine whether a patient's blood serum contains the specific immune substance or amboceptor of syphilis.

The antigen may be an emulsion of the *Treponema pallidum,* which is the infecting micro-organism of syphilis or an extract of syphilitic liver tissue. As a matter of fact alcoholic extracts of heart muscle will serve as antigen although in no way associated with syphilis. The amboceptor or immune body in syphilis may or

may not be present in the patient's blood serum. For complement the blood serum of guinea pigs is used. If these three reagents are mixed in the proper proportions they will unite so that none of the complement will be left over, if the patient has syphilis. If the patient is not infected with syphilis the complement is still free and unfixed. To determine this, sheep's corpuscles and the serum of a rabbit immunized to sheep's corpuscles is added after the complement that is always present has been destroyed by heat. If the complement is used up then no hemolysis of the sheep's cor-



Antigen. — Amboceptor or immune body of syphilis. — Complement — Amboceptor of rabbit immunized to sheep's corpuscles. — Corpuscles of sheep.

If 2 is present, 1, 2 and 3 combine, no hemolysis occurs.
If 2 is not present, 3, 4 and 5 combine, and hemolysis takes place.

Fig. 15.—Schematic picture of complement fixation as it occurs on the Wassermann reaction.

puscles will take place and the test is said to be positive; if it is not, it will join with the rabbit serum amboceptor and dissolve the corpuscles and the test is negative.

The Kahn Test.—This is a direct precipitation test for syphilis made by mixing blood serum with concentrated antigen in definite proportions. A positive reaction for syphilis is indicated by the formation of a fine flocculent precipitate. This can be seen by holding the tube containing the mixture against a black background. In negative tests the mixture remains perfectly clear.

While this test is much simpler to do than complement fixation it is a reliable test but has not supplanted the Wassermann test from the standpoint of accuracy.

ALLERGY.

Hypersusceptibility.—Everyone is familiar with the idiosyncrasies of people to various drugs, foods, etc. Some persons are unable to take even small amounts of quinine without disagreeable symptoms following. Some are sensitive to foods like strawberries; others to pollens floating in the air. Such instances are very numerous. We can define hypersusceptibility as an injury resulting from exposure to substances which ordinarily have no harmful effect on normal people or animals. The hypersensitiveness to pollens and some foods may pass from parent to child.

All of the reactions that occur because of hypersusceptibility are grouped under the term *Allergy,* meaning an altered reaction. The substances causing these reactions are called *Allergens.* The first observation of hypersensitiveness in the field of bacteriology was made by von Behring in 1893. He noticed that animals made immune by repeated doses of diphtheria toxin would sometimes exhibit alarming symptoms if given another even smaller dose. Occasionally the animals died. Hypersensitiveness of this sort is called *Anaphylaxis* (meaning against protection and the exact opposite of prophylaxis).

ANAPHYLAXIS.

It was observed later that effects similar to those described could be produced in experimental animals

such as guinea pigs, rabbits, etc., by the injection of simple proteid substances like egg-white or milk. The first injection produces no injurious effect but the second injection, even when the dose is smaller, may cause the death of the animal. The first injection, then, sensitizes the animal but there must elapse a period of incubation for the hypersensitiveness to develop. This is about six days in animals but in human beings varies between ten and fourteen days. The explanation of this curious reaction is not entirely clear. When, during an attack of diphtheria, for example, the blood contains the toxin of diphtheria and then antitoxin is used, there is a union between them, which renders the toxin of diphtheria harmless. But the antitoxin is made in the horse and consequently contains horse serum which contains proteids that are foreign to human beings. So, with the first dose the patient becomes sensitized to horse serum in about ten days. If another dose of antitoxin with horse serum is given after ten days, an anaphylactic reaction is likely to develop. The symptoms of anaphylaxis are variable from the mildest to the most severe and fatalities have resulted. The onset may be sudden and follow immediately upon the introduction of the proteid material to which the person or animal is sensitized or it may be delayed for several days. In the acute shock there is fall of blood-pressure, spasm of the muscles in the bronchial tubes causing a choking sensation, and a fall of temperature. Experiments have proven that the shock of anaphylaxis is due to a spasm of the non-striated or involuntary muscle. The fatal reactions in man are believed to be due to spasm of the involuntary muscles about the bronchial tubes.

Asthmatic people are most likely to develop anaphylaxis and great caution must be used in giving an antitoxin that contains horse serum for they may be hypersensitive to it and very serious reactions may result. As a precaution it is the general custom to make a skin test in all cases, before giving an antitoxin, to determine whether the patient is hypersensitive or not. This is done by giving an intracutaneous injection of 0.02 cubic centimeter of a 10 per cent. solution of horse serum, with a similar injection of salt solution as a control. The injection produces a wheal which in unsensitive people disappears shortly but in sensitive people it quickly increases, becomes raised above the skin, red, and persists from two to four hours.

Patients who exhibit this hypersensitive reaction must be desensitized before being treated, by injecting minute amounts of the antitoxin and slowly increasing them until they show no ill effects from moderate doses. It is possible to desensitize a person who is sensitive to a foreign proteid by the injection of the proteid in very minute doses at first and slowly increasing them.

Serum Sickness.—A peculiar reaction quite frequently follows the administration of antitoxic serum such as is used in diphtheria, tetanus, and pneumonia. Even with a single injection in from seven to fourteen days the original point of injection becomes swollen, there is fever, and a generalized urticaria or hives. Frequently any movement of the joints becomes painful. The reaction lasts several days and may make the patient very uncomfortable. This condition is called "serum sickness" and is transitory and not fatal.

Skin Reactions.—Skin reactions like those occurring with the use of horse serum also result from the injection of the toxins of various bacteria in patients sensitive to them. The toxin of the tubercle bacillus—tuberculin—is widely used to detect people oversensitive to it. It has proven to be a very valuable test for tuberculosis, particularly in children. The Schick test in which the toxin of the diphtheria bacillus is used is another valuable skin test for the detection of children susceptible to diphtheria. The Dick test for scarlet fever is a similar reaction.

Hypersensitiveness to pollens is often the cause of hay fever. Asthma is frequently caused by a similar hypersensitiveness to dust and proteids of food. In the case of hay fever it is now possible to desensitize patients by the injection of gradually increasing amounts of extracts of the pollens. It is possible by skin tests to determine what pollens patients are susceptible to and to desensitize them accordingly. With asthmatics it is sometimes possible by skin test to find the kind of dust or proteid causing the trouble and to eliminate it with much benefit to the patient.

Questions in Review.

1. Define: Antigen, complement and amboceptor.
2. How is complement fixation used in the diagnosis of disease?
3. Define: Allergy and anaphylaxis. Give examples of each.
4. How may the danger of anaphylaxis be avoided?
5. What are the symptoms of serum sickness and what are they due to?
6. How may hypersensitiveness be used in the diagnosis of disease?

CHAPTER IX.

PATHOGENIC BACTERIA.

INTRODUCTION.

In the following chapters the characteristics of the individual species of bacteria associated with the production of disease will be considered. Many of these pathogenic bacteria cause specific infectious disease like typhoid fever, tuberculosis, gonorrhea, plague, and cholera. Others may cause infections of widely different character depending upon the location of the infection, as, for example, the infection caused by the staphylococcus. If the infection is *on the skin,* it may be an impetigo; *in the skin,* a boil, in the bone marrow, an osteomyelitis, and so on.

It is a fact that the more one knows of the characteristics of the individual pathogenic bacteria, their method of growth and transmission, the toxins they produce, and the effect of the toxins on the tissues, the better one can understand the infectious diseases caused by them.

Sporadic, Epidemic, Endemic Infections.—Infectious disease may occur singly, when it is called sporadic, or it may develop in a large number of people at one time giving rise to an epidemic. When an infectious disease occurs in a community constantly over a long period, affecting only a few at one time, it is said to be endemic. The bacteria that cause infectious diseases that occur in epidemic or endemic form may be transmitted in a

variety of ways; by water or food, by contact, or by carriers. To check the spread of such infectious diseases a thorough knowledge of bacteriology is necessary.

To safeguard the community against the spread of infectious disease, each case, as it occurs, must be reported to the Bureau of Health. From the distribution of such reports the onset of epidemics can be detected; contacts and carriers can be investigated; water and food supplies examined. This work forms a considerable and very important part of the duty of the modern health bureau. In the larger cities this work is done by the Department of Epidemology of the Health Bureau.

THE GROUP OF PYOGENIC COCCI.

It is convenient to divide the bacteria causing infectious disease into groups; the members of each group being closely related in their growth, morphology, and manner of producing infection. Thus there is the group of pyogenic cocci (pus forming cocci) and the intestinal or the typhoid and dysentery group. On account of their wide distribution and the frequency with which they cause infection, the members of the pyogenic group will be considered first.

This group is composed of the following microorganisms: the staphylococcus, the streptococcus, the gonococcus, the pneumococcus, the meningococcus, the *Micrococcus tetragenous,* and the *Micrococcus catarrhalis.*

Staphylococci.

The coccus that most commonly causes infection is the staphylococcus, so named because of its characteristic arrangement into clusters often likened to bunches of grapes. (See Fig. 16.) Several varieties are distinguished by the pigment they produce when grown in

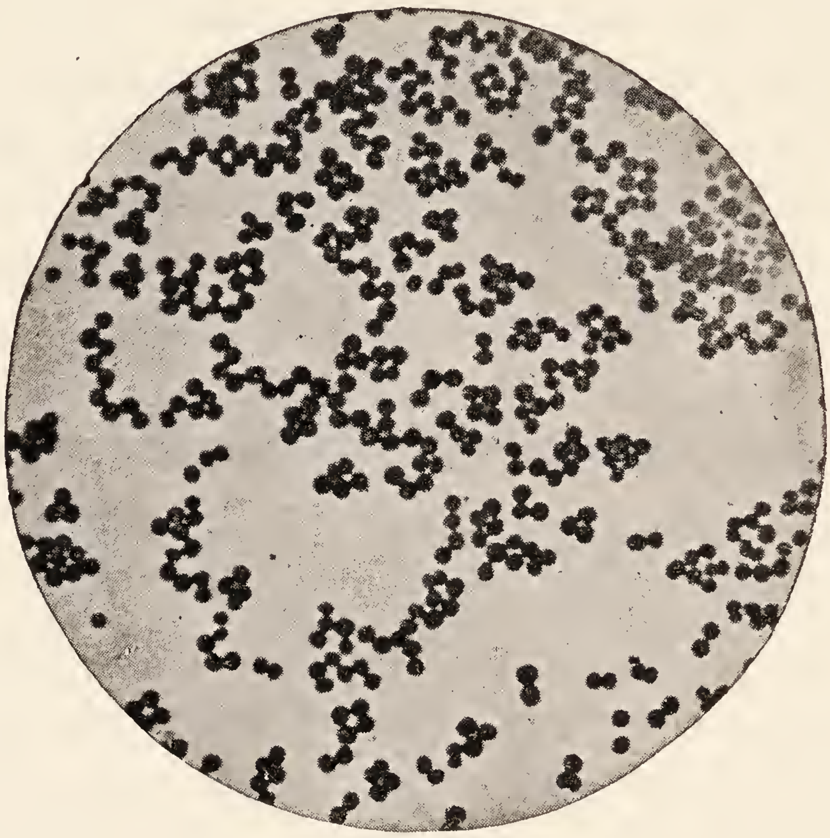


Fig. 16.—Staphylococcus pyogenes aureus. (Zinsser, after *Gunther*. D. Appleton & Co.)

cultures. The *Staphylococcus aureus* produces a golden-yellow pigment, the S. citreus, a lemon-yellow pigment, while the S. albus grows without forming any color. The *Staphylococcus epidermidis albus* is a variety found in the under layers of the skin. The size of these coccus forms differ, some being larger than others. They do not form spores, all are without motility, and all are Gram-positive. They grow readily on a variety of culture media at body temperature. They are aërobic but

will grow under anaërobic conditions. The formation of the pigment, characteristic of the various members of the staphylococcus group takes place only in the presence of oxygen.

Staphylococcus Aureus.—The aureus is the most virulent of all staphylococci. The infections caused by the staphylococci vary with the virulence of the organism and the resistance of the individual infected. The infection may be local like a boil or an abscess, or it may extend to involve large areas of tissue (cellulitis).

Local infection with the staphylococcus is very common. The organism seems to be present on the skin most of the time and gains entrance by friction or irritation into the hair follicles, sweat and sebaceous glands causing boils or furuncles. The lowered resistance of the individual is also an important factor in these local infections. Indoor occupations, diet too rich in starch food, overwork, and debilitating diseases like diabetes and nephritis, tend to lower the resistance enough to allow local infections to develop. Local infections about the nose and upper lip are particularly dangerous as they show a marked tendency to spread upward and not infrequently terminate in a meningitis, causing death in three or four days after the onset. Superficial skin infection is common about the face and is called impetigo contagiosa. Other infections caused by the staphylococcus are osteomyelitis or suppuration of the marrow cavities of long bones, and ascending infection of the urinary bladder and kidney.

General infections, septicemia, and pyemia are very often caused by these organisms. Malignant endocarditis and puerperal fever come under this head. They

are usually the cause of infection in wounds, although there are other bacteria that may do this.

Staphylococcus Albus.—The *Staphylococcus albus* differs from the aureus in the absence of pigment but in other respects is identical. In general it is less virulent although occasionally it causes very serious infection. Such an instance came under the writer's observation recently. It was a general infection or septicemia originating in a simple scratch on the knee. The blood cultures made from the patient showed enormous numbers of the organism in the circulating blood. The average number of colonies growing in the blood plates was over thirteen hundred. The infection terminated fatally.

The *Staphylococcus epidermidis albus* is a variety of the albus found in the skin and is frequently the cause of stitch abscesses in surgery. The *Staphylococcus citreus* produces a lemon-yellow pigment in cultures. It is identical with the other members of the group except that it has little virulence and is seldom the cause of infection. The *Micrococcus tetragenus* is a pus-forming organism of low-grade virulence. Its arrangement is peculiar, forming squares of four cocci. It is found frequently in the sputum and causes infection usually in combination with some other micro-organism.

Toxins.—The injury caused in infections by the staphylococci is due almost wholly to the toxins in part set free and in part retained in their cell bodies and liberated in their dissolution after death. The toxins are two, one that is hemolytic and results in the destruction of the red blood cells. Another toxin exerts a marked destructive action on the leucocytes and is

called leucocidin. Within the body of the staphylococcus either living or dead is some substance that has an attraction for the white blood cells. Consequently infected tissue is engorged with these cells. The toxins cause the formation of pus and also attack the red blood-cells, dissolving them (hemolysis). This explains the anemia that always accompanies these infections.

Immunity.—It is possible to immunize animals to cultures of the staphylococcus by the injection of slowly increasing doses of the killed organism. This cannot be done so successfully in human beings. In subacute and chronic infections killed cultures or vaccines are used extensively to produce active immunity with considerable success, particularly in furunculosis. Efforts to produce an efficient antitoxin have not been successful.

Precautionary Measures.—It is to remove all bacteria, especially the pus-cocci coming in contact with the patient, that the precautions or technic of the operating room is directed. Since the pus-cocci are so often found on the skin, careful washing and scrubbing of the hands followed by a disinfectant is employed to destroy them. It is important to remember that these precautions cannot be safely performed in a careless manner, as the pyogenic cocci may be located *in* rather than on the skin. They are resistant to drying and will remain alive about three months on paper or cloth. They are killed in a 1: 1000 solution of bichloride of mercury in ten minutes.

The Streptococci.

The streptococcus is one of the group of pus-forming cocci; characterized by multiplication in one plane, producing strings or chains of cocci. These cocci are Gram-positive. They are found in water, dust, and the intestinal discharges of man and animals. They are also present in the mouth and throat of many healthy people. They are usually easy to grow on ordinary culture media at body temperature and in the presence of oxygen. Certain varieties require media enriched by the addition of glucose and whole blood. One important characteristic is that they are not soluble in bile. This serves to distinguish the streptococcus from the pneumococcus with which it may be confused. A temperature of 54° C. for ten minutes kills the streptococcus but they are very resistant to cold. Bichloride of mercury in 1 : 500 solution and lysol in 1 : 200 will kill them in fifteen minutes.

There are many varieties of streptococci which may be divided into two large groups depending on their faculty of dissolving red blood cells, viz.:

I. The non-hemolytic streptococci.

II. The hemolytic streptococci.

Numerous individual members of these groups have been found which vary from one another in their shape, staining peculiarities, virulence, and agglutination reactions.

Non-hemolytic Streptococci.—The non-hemolytic streptococci are widely distributed in the body but they are not so virulent or invasive as the hemolytic streptococci. They are rarely the primary cause of infection.

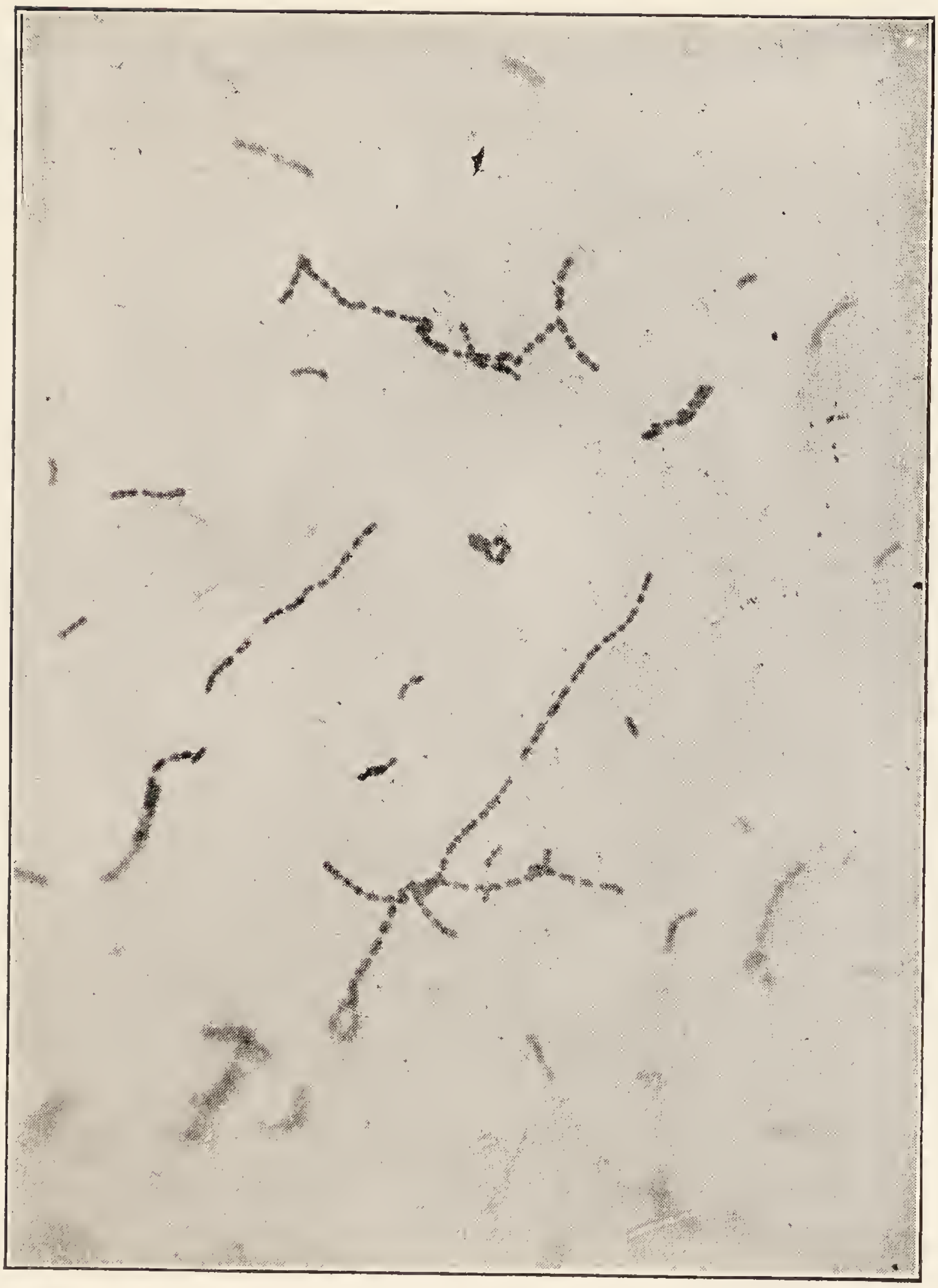


Fig. 17.—Streptococcus pyogenes. (Zinsser. D. Appleton & Co.)

One member of the non-hemolytic group, the *Streptococcus viridans,* is peculiar in possessing the property of changing hemoglobin into methemoglobin when grown on artificial culture-media; the colonies have a greenish zone about them. They are often found in the abscesses at the roots of teeth, in nasal sinus infections and in the tonsils. Vegetative endocarditis is often the result of infection with this organism. In this condition the lining of the heart and heart valves become roughened by tiny excrescences or vegetations in which the organism can be found in great numbers. It is usually possible to cultivate the organism from the circulating blood in these cases.

It has been asserted by some that acute rheumatic fever is an infection with the *Streptococcus viridans.* The organism has been cultivated from the joints of such cases. The frequent association of endocarditis and acute rheumatic fever lends support to such an assumption. Not enough evidence has been submitted up to the present time in proof of this.

Hemolytic Streptococci.—The characteristics of the hemolytic group include their high degree of virulence, the property of dissolving red blood-cells, and their tendency to produce epidemic infections. They are rarely present in the human body under normal conditions.

Infections with the *Streptococcus hemolyticus* include boils and abscesses. There is usually, in severe infections of this kind, an extension of the infection along the lymph channels which become visible under the skin as red lines. More serious infections are erysipelas, peritonsillar abscess, otitis media, mastoiditis,

Fig. 18.—Blood culture plate showing streptococcus colonies with zone of hemolysis about each. (Zinsser. D. Appleton & Co.)

infections of bones, puerperal fever, septic sore throat, and scarlet fever. Meningitis and brain abscess may be secondary to streptococcus infections elsewhere in the body. These infections just mentioned are always grave and are attended by a higher rate of mortality than similar infections caused by the staphylococcus. Septic sore throat occurs in epidemic form and can be traced usually to milk. The streptococcus finds its way into the milk from the infected udders of cows.

Toxins.—The injury resulting from *Streptococcus hemolyticus* infection is due to the toxins secreted by the organism. They are powerful, as shown by the high temperature, rapid pulse, chills and sweats which are the accompaniments of severe toxemia. One of the toxins is an hemolysin that causes laking or dissolution of the red blood cells. The presence of this toxin can be demonstrated in cultures made in bouillon by mixing the culture and red blood corpuscles in the test-tube. It has been given the name streptolysin. Another toxin is called streptoleucocidin and is destructive to the leucocytes of the blood.

Immunity.—Acquired immunity following these infections, if it occurs at all, is of very short duration. In animals, however, it has been possible to produce an active immunity in horses and the serum of the animals so immunized can be used to produce passive immunity in human beings.

The results obtained from the use of antistreptococcus serum or antitoxin have been disappointing with two notable exceptions, the antitoxin for scarlet fever and the one for erysipelas. The difficulty lies in the fact that there are many strains of streptococci, and, unless

the serum contains the protective substances for the particular strain causing the infection, no successful result can be expected.

The Streptococcus of Septic Sore Throat.

This streptococcus belongs to the hemolytic group and is called the *Streptococcus epidemicus.* It causes an infection of the throat with redness and edema of the tissues. The onset is sudden. There is also headache, fever, chills, and bone pains. Occasionally skin rashes simulating scarlet fever occur. It lasts from ten days to three weeks. The disease has been confused with influenza because of the similarity of the symptoms. There may be a remission of the symptoms which recur with the onset of complications such as arthritis, peritonitis, otitis media, pericarditis and endocarditis.

Cause.—The infection is usually spread in raw milk and the streptococcus gains entrance to the milk from a cow that has an infected udder, although it is possible for milk to be infected from a milk handler having the disease. Numerous epidemics of septic sore throat have been reported. The most recent one occurred in Lee, Massachusetts, a small town of 4000 inhabitants. During the month of July, 1928, between 925 and 975 cases of the infection developed, most of them in the first week, with 48 known deaths. The cause of the infection was traced to an infected cow by workers from the Massachusetts State Department of Health. They also found that a large majority of those taken ill used milk from the dairy which handled milk from the infected cow. Not all the cases could be traced to this source.

Without doubt a considerable number developed the infection from contact with the sick.

Prevention.—In the prevention of this disease attention should be directed first to the milk supply which must be boiled or pasteurized. Infected cows should be sought out and the milk excluded from the supply. Milk handlers should be examined for any trace of the disease. All those infected must be isolated. The infection develops no immunity of any duration. There is no antitoxin as yet that has proven of value. In communities using only pasteurized milk, such epidemics will not occur.

The Hemolytic Streptococcus of Scarlet Fever.

Although the streptococcus had often been found in the throats and, at times, in the circulating blood of scarlet fever patients, the majority of bacteriologists were of the opinion that these organisms were not the real cause of the disease, but occurred only as secondary invaders. The constant presence of the streptococcus in scarlet fever, however, led to a continued study of the question and eventually it was found that the blood serum of scarlet fever patients contained a substance that agglutinated the streptococcus found in scarlet fever patients, but did not agglutinate others. Thus it was established that scarlet fever patients were infected with a definite type or strain of hemolytic streptococcus.

The Dick Test.—Inoculation experiments with this type of streptococcus were not very successful in animals but those made on human beings, who volunteered for the tests, were successful. These tests were made

by the Dick brothers in 1923 and were responsible very largely for the acceptance of the *Streptococcus hemolyticus* as the cause of scarlet fever. In broth cultures this streptococcus develops a toxin which is contained in the broth. If the organisms are filtered out, the fluid that passes through the filter (filtrate) contains the toxin. If this toxin is injected into the skin it will produce a reaction, marked by redness and edema in those who are susceptible to scarlet fever. This is known as the Dick test and is of great value.

Immunity.—In those who are susceptible, attempts have been made to produce an active immunity by the injection of the toxin in small but increasing doses. The results have been very encouraging and lead to the hope that it may be possible to immunize children successfully to this disease. This immunity persists for about one and one-half years.

Antitoxin.—The use of antitoxin producing passive immunity has been developed in this country by Dr. Dick and by Dr. Dochez, working independently. The antitoxin is produced in horses by immunizing them to the toxins. When immunity has been established in the horse, the blood serum of the animal contains the antitoxin.

Patients with scarlet fever respond remarkably well to treatment with the antitoxin. The rash fades, the throat clears, and the temperature and other symptoms of toxemia subside. The complications of the disease, too, occur less frequently. The antitoxin is given intravenously and, because of the horse serum content, it is necessary to make a preliminary skin test to avoid the danger of anaphylaxis.

How Scarlet Fever is Spread.—Scarlet fever is spread in the discharges from the throat, nose and mouth. It is essential that these be collected and destroyed. They are infectious for three or four weeks and long after the rash has disappeared. If complications exist, such as discharging abscess of the ear or mastoiditis, the discharges may be infectious over a much longer period.

Carriers.—There are, in all likelihood, carriers of the scarlet fever streptococcus that infect others. One other cause of the spread of the disease is the mild case, so little disturbed by the infection, that it goes unrecognized. These patients, nevertheless, are capable of infecting others. Scarlet fever is one of the diseases that may be transmitted in milk but pasteurization of the milk renders it non-infectious. (See Chapter on Milk.)

The Streptococcus Erysipelatis.

Erysipelas, the infection caused by this organism, has been familiar to physicians for many years. Hippocrates gave an accurate description of it in his writings.

The cause of the infection remained obscure until 1882 when Fehleisen described the streptococcus found in the inflamed tissue. The recent work of Dr. Birkhaug proves that the organism belongs in the class of hemolytic streptococci, differing from other streptococci and specific for erysipelas. The disease may be reproduced in experimental animals. It produces a soluble exotoxin and an endotoxin as well. Susceptibility to the infection may be detected by the injection of a dilute solution of

the soluble toxin into the skin where it produces a characteristic skin reaction.

The disease occurs everywhere and at times is epidemic. It occurs more often in hospital than in private practice. Surgical patients and women after childbirth seem particularly susceptible.

Symptoms.—The incubation period is short, fifteen to twenty-one hours. The onset is sudden, often marked by a chill, and rapidly mounting temperature. The infection is located in the deeper layers of the skin and spreads by extension along the lymph channels. The glands become swollen. The streptococci may be carried to other organs to cause complications of more serious nature, such as endocarditis, pneumonia and general septicemia.

The infection is not particularly fatal except in the old and feeble and in infants.

Immunity.—An antitoxin which is used both for creating passive immunity and for curative purposes can be made in horses. The reports of cases in which it has been used indicate a marked curative effect and a reduction of 50 per cent. in the fatal cases. It is given intramuscularly.

The immunity following erysipelas is of short duration, usually six weeks. In fact, one attack seems to predispose to subsequent attacks. Instances of habitual erysipelas are known. Active immunity by the injection of slowly increasing amounts of the toxin in such cases has been done recently with successful results.

Questions in Review.

1. Define the terms: Epidemic, sporadic and endemic.

2. What organisms comprise the pyogenic group of bacteria?

3. Name the various infectious conditions caused by the staphylococcus and the streptococcus?

4. Why is anemia a prominent feature of staphylococcus and streptococcus infections?

5. How may the various staphylococci be differentiated?

6. How may the various streptococci be differentiated?

7. For what three types of streptococcus infection have antitoxins been produced?

8. How is septic sore throat usually contracted?

9. What is the Dick test?

CHAPTER X.

THE GONOCOCCUS, PNEUMOCOCCUS, MENINGOCOCCUS AND MICROCOCCUS CATARRHALIS.

THE GONOCOCCUS.

The gonococcus is the organism causing gonorrhea, which is classed as a venereal disease because it is transmitted chiefly through sexual contact. It produces in adults a purulent discharge of the genital organs. The gonococcus is a diplococcus, always occurring in pairs with the surfaces facing one another, flattened like two coffee beans. It does not retain the stain by Gram's method. When smears of the pus are examined the gonococci are generally found within the bodies of the leucocytes.

It is a difficult organism to grow on culture media. A special medium is necessary that contains ascitic fluid, hydrocele fluid, or blood serum. For clinical purposes it can be identified by its being Gram-negative, a diplococcus, intracellular, and not possible to cultivate on ordinary media. For medico-legal proof culture identification and complement-fixation may be tried.

Immunity.—The gonococcus is readily destroyed by disinfectant solutions. It is killed by drying in a short time and has little resistance to heat. The disease cannot be produced experimentally in animals. Very little immunity develops from the infection. It has been possible to immunize animals to the gonococcus and suc-

cessful results in the treatment of patients with the serum of such animals have been reported. This method of treatment has been employed very little up to the present time. Active immunization with killed cultures of the gonococcus has been in use for some years. It has little effect when the infection is acute. In chronic cases it has proven to be of some benefit.

Gonorrhea is an exceedingly common disease. Some conception of its prevalence is gained from the report of the Surgeon General of the United States Army for 1918, during the world war. There were 167,475 or 66.5 cases of gonorrhea per 1000 among the troops. In civil life the number existing from year to year is probably somewhat less than this. The extent to which infections with gonorrhea and the other venereal diseases developed during the war was the chief factor in starting a nation-wide campaign by the United States Public Health Service to combat the incidence of this and other venereal diseases. The chief factor in this campaign is the education of the public to the facts about gonorrhea and the disastrous results that follow in its wake. State departments of health are co-operating and have established in the cities free clinics for the treatment of those infected.

Symptoms and Duration.—The nurse is often asked by her patient about this disease. The nurse, therefore, should know the following facts about gonorrhea. In the male the infection starts, after an incubation period of five to seven days, with a discharge of pus from the urethra. The acute stage lasts usually from three to six weeks, and then recedes either entirely or leaves a catarrhal inflammation which may last and be infectious

for an indefinite period. In approximately half of the cases, however, the infection extends back to involve the bladder, prostate gland, or seminal vesicles. When this happens the gonococci become buried in the tissues and frequently remain dormant for years, only to light up again when conditions favor it. Infection of these organs is most difficult to eradicate, and a person so infected may be able to transmit the disease to others over long periods of time. It is a frequent cause of sterility in the male. In the female the infection, during menstrual life, starts in the cervix of the uterus, less often in the urethra. It frequently involves Skene's ducts about the urethral orifice and Bartholin's glands beneath the floor of the vagina. The disease has the tendency to ascend during the menstrual period to involve the mucus lining of the uterus, thence to the Fallopian tubes and ovaries. When this occurs it nearly always requires surgical intervention. The disease is harder to combat in the female than in the male, partly because the acute symptoms are not so marked, and so the nature of the infection may escape detection, and partly because the anatomy of the organs infected is such that it is next to impossible to treat the infection thoroughly. The period over which the disease may continue infectious in the female may be years, and if the tubes and ovaries are involved sterility usually ensues.

While the infections with the gonococcus, in both men and women, are generally confined to the genital organs, they occasionally become general infections, causing arthritis, endocarditis, and meningitis.

Ophthalmia.

Gonorrheal infection of the eyes is fairly common. It occurs in the newborn most often, and is called ophthalmia neonatorum. Ulcers on the cornea which interfere with vision in later life, or complete destruction of the eyeball, may result. It is the chief cause of blindness in children. The infection gets into the eyes during delivery, and as a prophylactic measure it is advisable to instill a drop or two of 1 per cent. nitrate of silver into the eyes of *every* child immediately after birth. In adults the infection is usually introduced by infected fingers, handkerchiefs, or towels.

Vaginitis.

Among children in institutions gonorrheal infection of the vagina, vaginitis, occurs in epidemic form. It spreads from child to child with great rapidity, and is very difficult to check. The infection starts from one child so infected, and is spread by napkins, towels, or directly from one child to another. It is very difficult to overcome by any method known at the present time. The use of the gonorrheal vaccine has given as good results as any form of treatment. One interesting fact is that a remission of the vaginal discharge may take place during treatment only to recur with the onset of the infectious diseases of childhood like measles, chickenpox, and so on. The infection disappears spontaneously with the onset of the menstrual cycle.

THE PNEUMOCOCCUS

Pneumonia is an acute infectious disease caused by a variety of micro-organisms, the chief one being *Diplococcus pneumoniæ,* or the pneumococcus. Other bacteria, such as the streptococcus, staphylococcus, the influenza bacillus, the Friedlander bacillus, and typhoid bacillus, may also cause pneumonia. The pneumococcus is a

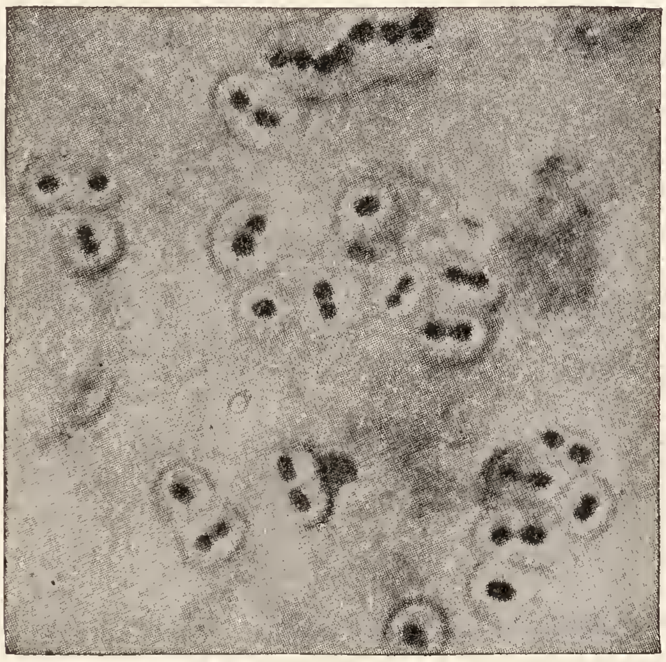


Fig. 19.—Pneumococci showing capsules grown on Löffler's serum. (Zinsser. D. Appleton & Co.)

small lance-shaped organism arranged in pairs. These diplococci may form chains not unlike the streptococcus in appearance. It is an encapsulated diplococcus, the capsule being easily stained in smears of the fresh sputum.

The pneumococcus grows best at body temperature. It is dissolved in bile, while the streptococcus, with which it is easily confused, is not. It is Gram-positive. It is non-motile, forms no spores and stains easily. To demonstrate the capsule special staining methods are

required. It grows best on media containing meat infusion to which blood serum or whole blood has been added. The colonies of the pneumococcus on blood media have a slightly greenish color and have a narrow zone of hemolysis about them. The growth dies out quickly in culture media unless frequently transplanted.

Types of Pneumococci.—Four types of pneumococci are recognized, called Types I, II, III and IV. The first two are distinct clear cut types. Type IV is a mixture of many strains of the pneumococcus that do not fall in any of the first three. Type III is in many ways like a streptococcus, having a tendency to form chains. It is sometimes called the *Streptococcus mucosus*. Because of its solubility in bile and its fermenting action on certain sugars it is more accurate to place it in the group of pneumococci.

Finding the Type.—The method of determining the type of pneumococcus present in any given case of pneumonia is briefly as follows:

From the sputum a pure culture of the pneumococcus is obtained either by inoculating mice, which are very susceptible to pneumococcus infection, and cultivating the pneumococcus from the mouse peritoneum or by inoculating special media (Avery) with the sputum. With the pure culture of the pneumococcus, agglutination tests are made, mixing the growth with equal amounts of each of the three types of immune sera. If one of the sera agglutinates or clumps the pneumococci the test is positive for that particular type. If the pneumococcus culture is not agglutinated by any one of the immune sera it belongs in Type IV.

Precipitin tests may also be made. The precipitating substance is contained in the peritoneal washings of mice or in the culture fluid. They are also present in the sputum and urine. These are centrifugalized to render them perfectly clear and they are mixed with the immune sera. If precipitation occurs with any one type of serum the pneumococcus belongs to that type.

Type I pneumococcus is responsible for the largest number of pneumonia cases, while Type II is the most fatal. Type IV is frequently found in the throats of healthy people and is the least virulent of all.

Infection.—Infection with the pneumococcus takes place in two-thirds of the cases from outside the body, either directly from other patients or from infected dust. Carriers may transmit the infection but only to a limited extent.

While the chief point of infection is in the lungs, the pneumococcus can be cultivated from the circulating blood in a large proportion of the cases, indicating a general infection. The outlook for recovery is not favorable when there is septicemia. With this in mind the occurrence of complications such as otitis media, pericarditis, endocarditis, meningitis, arthritis, and osteomyelitis, are readily understood. Infections with the pneumococcus can occur in other parts of the body without pneumonia.

Pneumonia is a communicable disease. For many years, because pneumococci were present in the mouths of many people in health, it was believed that when pneumonia did arise it was caused by these organisms. This we know now is not correct. There have been numerous epidemics of primary pneumonia in military

camps, mining camps, and crowded communities, where considerable numbers of people live in crowded and unsanitary conditions. The disease here is transmitted from one to another, as proven by the fact that the type of pneumococcus found in the mouth does not always correspond with that found in the sputum in pneumonia. The pneumococcus may be transmitted from one person to another by direct contact with a case of pneumonia or from a carrier, usually a convalescent.

Prevention and Precautions.—To limit the spread of pneumonia the patient should be isolated at once. In hospital practice the patient should be screened. The sputum should be collected in paper boxes or napkins and burned. The hands of the patient should be kept clean with disinfectant (bichloride of mercury solution 1 : 1000) and the bed clothing disinfected. Rooms and apartments that have been occupied by pneumonia patients should be disinfected before being reoccupied.

Immunity.—The immunity acquired by man during an attack of pneumonia is of short duration. It has been possible, however, to produce an active immunity in horses by inoculating them, first with dead and later with living cultures of the pneumococcus, Type I. The serum of such animals is protective to man only in the case of Type I infections, although Type II cases may occasionally be benefited. The type of pneumococcus infection in any given case must be determined promptly for this reason.

Serum Treatment.—The serum is given intravenously. The first dose recommended is 100 cubic centimeters diluted to 250 cubic centimeters with normal salt

solution. This may be repeated every twelve hours for three or five doses, or more if necessary. The injection of the serum may be followed immediately by a chill and further rise of temperature in about one-third of the cases. After a few hours the temperature usually falls to a point lower than before and the symptoms abate. Each patient must have a preliminary injection of the serum in the skin to detect any hypersensitiveness to horse serum as outlined in the discussion of anaphylaxis on page 84.

The results of serum treatment depend on administering the serum at the earliest possible moment. The earlier it is given the greater the benefit derived. It is advisable to have the sputum or the blood culture typed and the diagnosis of Type I made. But in localities where this cannot be done promptly it is better to give the initial dose of the serum at once. It need not be continued if the infection later on proves to be of some other type. The use of this antitoxin is followed in about half the cases by serum sickness; skin rashes, elevation of temperature, and painful joints. This comes on about a week afterward and is of short duration.

Active Immunity.—Efforts have been made in the army to immunize troops to pneumococcus infection by the use of vaccines containing many different strains of pneumococci. Favorable results have been reported but the time elapsed is too short to make any very definite statement as to its efficiency.

THE MENINGOCOCCUS.

Cerebrospinal Meningitis.

Cerebrospinal meningitis is an infectious disease in which the agent of infection produces an inflammation of the covering of the brain and spinal cord. The infection may be caused by any one of a number of microorganisms; the pneumococcus, the typhoid bacillus, the influenza bacillus, the tubercle bacillus, the streptococcus or staphylococcus pyogenes. When the meningitis results from infection with these organisms it is generally secondary to an infection elsewhere in the body, as, for example, during pneumonia, typhoid fever, pulmonary tuberculosis, or septicemia.

Spotted Fever.

The primary form of meningitis, the form that frequently occurs in epidemics and is more commonly called spotted fever, is due to infection with the meningococcus or the *Micrococcus intracellularis meningitidis,* and must not be confused with the forms mentioned above, which are always secondary.

Morphology.—The meningococcus was identified and described by Professor Weichselbaum in 1887. The micro-organism was found in the cerebrospinal fluid of patients sick with the disease, and generally within the bodies of the leucocytes. For this reason the term intracellular is used in its description. The coccus occurs in pairs, a diplococcus, which in appearance is not unlike the gonococcus. It is Gram-negative. It can be cultivated on agar containing blood or ascitic or hydrocele fluid. Two types of the meningococcus are

recognized, the meningococcus and the parameningococcus, with numerous intermediary strains.

Diagnosis.—The presence of the disease is detected by finding the meningococcus in the cerebrospinal fluid, which is withdrawn by inserting an aspirating needle into the cerebrospinal canal, at the level of the third or fourth lumbar vertebra. This procedure is spoken of as lumbar puncture, and may be performed by physicians without danger to the patient. The fluid recovered in this manner is usually cloudy and is immediately centrifuged to throw down the cellular elements contained in it. After this has been done the deposit is spread thinly on slides, stained by Gram's method, and examined under the microscope. The meningococcus when present is identified by its shape and arrangement in pairs, and by its location within the bodies of the leucocytes. Sometimes no organism of any kind can be found. This may be due to the destruction of the meningococcus in the spinal fluid. The microorganism may be cultivated from the spinal fluid on media enriched by blood serum or ascitic fluid. In addition to its use as a diagnostic aid, lumbar puncture is very often the means of relieving the symptoms of pressure due to an excessive amount of fluid in the spinal canal, and for this reason it is customary to remove a large amount of the fluid.

Infection.—The meningococcus is spread by the discharges from the mouth, nose, and ears of patients sick with meningitis, and it is not unusual to find the organisms in the secretions of the nose and mouth of those attending them. Occasionally they may be found in the nasal secretions of healthy people who may act

as carriers. In fact, carriers are now believed to be the chief source of infection.

Prevention.—To prevent the disease from spreading it is essential first of all to remove the patient from contact with others, especially during the first two weeks of the disease, for at this period the infection is most virulent. Then all discharges from the mouth, nose, eyes, and ears should be collected and burned. Cultures should be made from the nasopharynx of those who have been exposed to the infection and those persons in whom the meningococcus is found should be isolated. The danger of nurses contracting the disease from patients is slight if care is used to disinfect the hands after handling the patient and an antiseptic spray is used in the nose and throat. Children living in the same house should not be permitted to attend school until it is certain that they have not been infected.

Serum Treatment.—Cerebrospinal meningitis in the epidemic form has been attended with a very high mortality in the past, especially among young children. In some epidemics it has been as high as 90 per cent., the general average, however, is about 70 per cent. The treatment with antimeningitis serum, however, has been attended with success, and the mortality rate reduced to about 18 per cent. in cases treated during the first three days of the disease, and 36.5 per cent. in those treated after the seventh day. In this country this method of treatment was begun by Dr. Flexner and Dr. Jobling at the Rockefeller Institute in New York. The serum is made by injecting horses with slowly increasing doses of a mixture of many strains of the meningococcus that have been killed by heat. The

tolerance of the animals to the poison of the meningococci is gradually increased in this way until they are able to withstand many times the fatal dose. This tolerance depends upon an active immunity due to the formation within their bodies of protective substances that neutralize the poison. After eight or twelve months the horses are bled and the blood serum containing the protective substances is used for treating patients sick with meningitis.

The extended trial of the serum in a number of epidemics has shown that the earlier it is used after the onset of the infection the greater its curative value. For this reason it is customary to inject the serum immediately after the withdrawal of the cerebrospinal fluid by lumbar puncture, if it is cloudy, without waiting to determine the nature of the infecting organism. The serum should be given every twelve hours in severe cases until the spinal fluid becomes clear and the meningococcus is no longer present. The amount of serum to be given at one dose is dependent upon the age of the patient and the amount of serum withdrawn. In children, 10 to 20 cubic centimeters may be given; in adults, 30 to 40 cubic centimeters. It is unsafe, however, to give more serum than is removed by lumbar puncture.

The *Micrococcus catarrhalis* closely resembles the meningococcus but it is much easier to cultivate and grow at room temperature. It is found in the nasal secretions of healthy people and is probably responsible for nasal and bronchial infections similar to influenza. It has been the cause of epidemic conjunctivitis.

Questions in Review.

1. What characteristics are made use of in the identification of the gonococcus?

2. How does gonorrhea produce sterility?

3. Name the various organisms that may cause pneumonia?

4. How may the pneumococcus be differentiated from the streptococcus?

5. Outline the methods used in determining the type of pneumococcus present in sputum?

6. Of what advantage is it to know the type of pneumococcus infection?

7. What precautions should be taken in the care of the pneumonia patient?

8. What precautions should always be taken before pneumonia serum is given?

9. How should the nurse protect herself while attending a pneumonia patient?

10. Name the organisms that may cause meningitis. Which one causes the most infections? Which one is the most fatal?

11. How is the diagnosis of meningitis made? How is the antitoxin given?

CHAPTER XI.

THE BACILLI OF THE COLON, TYPHOID, DYSENTERY GROUP.

These organisms are usually grouped together because of the similarity in their appearance and manner of growth upon artificial culture media. They exhibit a wide variation, however, in their power of producing disease. All the members of this group are short, rod-shaped, often forming chains, but never forming spores. They all possess flagella and are motile. All are Gram-negative. They are distinguished from one another by the way they ferment sugars and produce acid in culture media, and by agglutination tests with immune sera.

THE BACILLUS COLI COMMUNIS.

Under the name of colon bacilli are grouped a number of organisms very closely related, which are usually harmless parasites living in the bodies of man and animals, but which at times become pathogenic and cause infection. The colon bacillus itself, properly called the *Bacillus coli communis,* is a constant inhabitant of the intestine in man and animals. In nature it is commonly found in soil, air, water, milk, and on grain. Just what function it performs in the intestine is not known positively, but it probably assists in breaking down food materials into simpler form so that they can be absorbed. Some believe that the colon bacillus elaborates a substance harmful to disease producing bacteria in the intestines.

Once the colon bacillus has invaded the walls of the intestine from an injury of some sort, it is capable of setting up an infection. It has been found to be the cause of abscess of the liver, inflammations of the gall-bladder, the urinary bladder, the pelvis of the kidney,

Fig. 20.—Fermentation tubes showing fermentation of sugar media by the *Bacillus coli communis.* (Zinsser. D. Appleton & Co.)

and the pancreas. It is frequently the cause of peritonitis in cases of ruptured appendix. Occasionally it causes a general infection. There is a septicemia that occurs in infants known as Winckel's disease that often proves fatal. The poisons of the colon bacillus are contained within the body of the organism and are liberated only when it disintegrates. The knowledge of this

fact has made it possible to immunize against colon infections by injecting the dead cultures, or vaccine, in slowly increasing doses. (See Immunity.)

On account of its constant presence in the intestine of man and animals, the presence of the colon bacillus in water or milk leads to the assumption that they have become infected with intestinal discharges, and so not safe for consumption. On account of the wide distribution of the colon bacillus in nature, this view has been modified to some extent, and now, unless they are present in excessive numbers, the water or milk is not condemned.

THE BACILLUS TYPHOSUS.

The typhoid bacillus is the cause of typhoid fever. In recent years we have come to recognize that there are a number of other micro-organisms closely related to the typhoid bacillus which produce a fever and other symptoms that make a clinical picture identical with typhoid fever. It is more accurate, therefore, to look upon the clinical condition of typhoid as being due to any one of a group of micro-organisms the chief members of which are the typhoid, paratyphoid, and dysentery bacilli, with forms intermediate between each.

Morphology.—The typhoid bacillus and other members of the group are short, delicate, rod-shaped organisms, with twelve or more flagella. They are actively motile. Observed under the microscope they can be seen moving rapidly across the field. Cultivation is simple because they grow on all the ordinary media at body temperature. Upon solid culture media the typhoid bacillus forms characteristic colonies that are

veined and are similar in appearance to a grape leaf. It does not ferment sugars with the production of gas.

The identification of the typhoid, the paratyphoid, and the dysentery bacilli in the stools and blood is now a routine procedure and is of much importance in the diagnosis of these diseases, the detection of carriers, and the control of convalescents. Owing to the diffi-

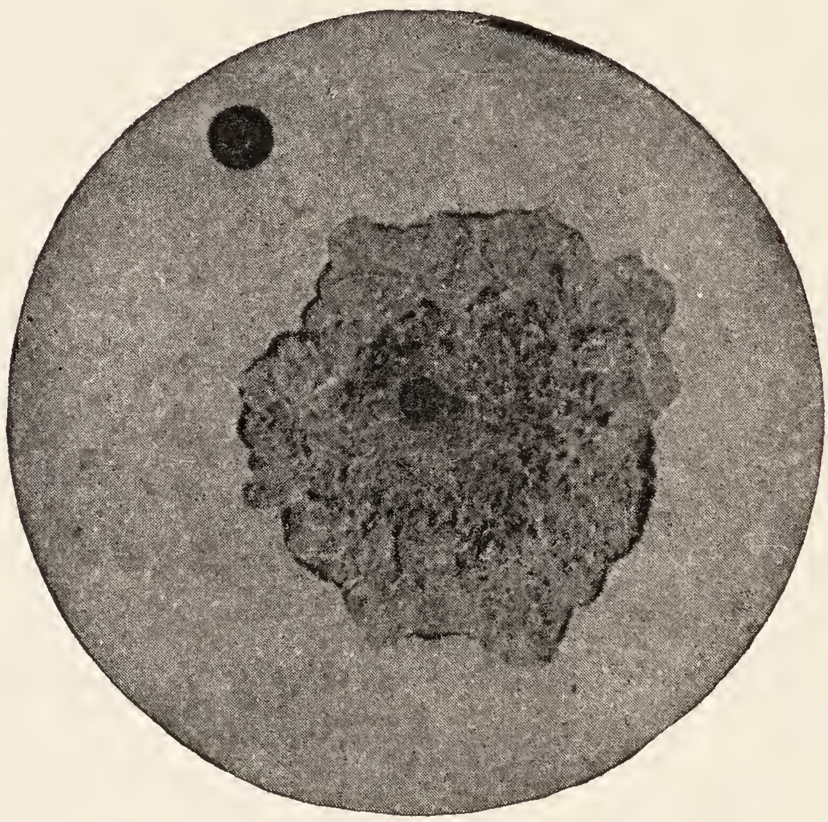


Fig. 21.—Surface colony of typhoid bacilli showing the characteristic veining and grape leaf appearance. (Zinsser, after *Heim*. D. Appleton & Co.)

culty of isolating the typhoid bacillus in stools more than twenty-four hours old, the specimen of the feces should be placed in a test-tube of sterile glycerol except when the examination can be made at once. To detect these organisms, mixed as they always are in the stools with excessive numbers of the bacillus coli, special media have been devised. The object of these media is to show the characteristic colonies of the typhoid bacil-

lus, the production of acid, and the differences in the fermentation with gas production, on the different sugars. By this means it is possible to differentiate the members of this group, one from another. The identification of these organisms developing in cultures of the blood is carried out in the same way.

The typhoid bacillus is both a saprophyte and a parasite. As a saprophyte it is widely distributed in nature, due to its ability to adapt itself to its environment. It will live in water, ice, sewage, milk, dust, air, and soil. In surface-water typhoid bacilli will live about a week, being rapidly overgrown by other bacteria, but in distilled water they will live for three months. Freezing will kill most of them in a few days. Experiments made by placing typhoid bacilli in ice prove that nearly all are killed in a week, but occasionally they live for three months. The bacilli will retain life for six months in the upper layers of the soil.

Within the body they can resist the action of the gastric juice and multiply in the small intestine, where the greatest amount of damage is done. During the disease the typhoid bacilli may be found in the circulating blood, spleen, mesenteric lymphatic glands, rose-spots, and occasionally in the sputum and vomitus. Typhoid fever should be considered not as a local infection of the intestine, but as a general infection with the organisms present in many of the organs and tissues of the body. In the bile, urine, and stools, the bacilli may persist for months and years after the acute infection has passed. It is for this reason that complications and sequelæ so frequently occur. The persistence of the typhoid bacilli in the bile is an important factor in the

production of gall-stones; the bacilli have been found in the centers of stones from ten to fifteen years after the infection.

The Path of Infection.—Infection with typhoid bacilli always occurs by way of the alimentary tract, by infected water or food. Added to the cause of infection there is usually a lowered resistance on the part of the individual.

Water.—The infection reaches the alimentary tract most often through infected water. As we have seen, typhoid bacilli will live for months in the soil; so that the discharges from typhoid patients that have not been disinfected and are deposited in or on the ground may lead to the infection of nearby wells and streams, particularly during periods of heavy rain. Water infected in this way, in the case of wells, may give rise to local epidemics, or to epidemics miles away in the case of streams. The epidemic of typhoid fever in Ithaca, N. Y., in 1903, was caused by the infection of the city water supply by a case of typhoid in a laborer's camp situated on the banks of the stream that fed the city reservoir; 1500 cases of typhoid occurred in a remarkably short time. There have been two epidemics in New York State recently, caused by defective cross connection between the drinking supply and the water supply to factories. The latter being unfiltered and not chlorinated caused the pollution of the city drinking supply. In Cohoes, N. Y., forty-eight cases were infected, nearly all living in a small section of the city. In Albany, N. Y., thirty cases were infected in the same way.

Wells are sometimes infected from privies, cisterns, and open cesspools when they are placed near a well, or when the natural drainage of the soil-water is in the direction of the well. Defective walls or coverings that admit surface-water render the infection of wells in this way more likely.

Milk.—Milk is an excellent culture medium, and typhoid bacilli will grow readily in it. They gain entrance to the milk by washing the milk cans or pails in infected water, or from the hands of persons sick or but recently recovered from the disease. Flies may also carry the infection to milk. There have been some 185 epidemics of typhoid traced to milk. In 1903 a milkman in Boston, sick with typhoid, spread the disease through the milk, causing an epidemic of over four hundred cases.

Uncooked Food.—The infection may be spread by eating uncooked vegetables that have been washed in infected water. Oysters and clams, when they have been grown in water contaminated with sewage, have been known to carry the infection. Along the seaboard, laws are now in force that prohibit the cultivation of oysters in water near the outlet of sewers.

Flies.—The importance of flies in the spread of typhoid has been recognized only in the last ten years. When they come in contact with typhoid patients, or with infected discharges, they carry the bacilli on their bodies and deposit them on foodstuffs.

Typhoid Carriers.—Finally, typhoid is spread by what are known as carriers, or persons that carry the bacilli in their bodies for a long time after they have recovered from the disease. About 4 per cent. of all

typhoid cases become carriers. The bacilli may be voided in the urine or passed in the stools. Dr. Park tells of a cook who was a carrier. During a period of five years she had been employed in six different families in which twenty-six cases of typhoid fever had developed, all within a month after her arrival in each family. A patient recently came under the writer's observation who had been operated for an inflamed gall-bladder. The wound remained open for several months before it healed. Nearly a year later an abscess developed deep in the abdomen beneath the scar. This was opened and in the pus the typhoid bacillus was found. One year later they were still present. On inquiry it developed that the patient had been infected nearly thirty years before. This patient was a chronic carrier, although no one else had been infected by him so far as could be learned. From the experience of recent years the number of typhoid infections resulting from contact with carriers is much greater than was formerly believed.

Prevention.—The prevention of typhoid infections relates to general measures to be enforced by the health bureau, and special precautions in the care of the patient sick with the disease. Prompt reporting of all cases to the health bureau is very necessary. It is obligatory in most countries. Each case should be investigated to determine the source of infection, whether from food, water, milk, or carrier. Water supplies must be safeguarded by filtration and chlorination. Kitchens must be screened against flies. Carriers must not be allowed to handle foodstuffs either in eating places or homes. All carriers must be registered in the health

department. In the New York State Department there were 157 carriers recorded at the end of the year 1928.

Precautions.—To limit the spread of typhoid fever, precautions should be taken to render all food materials and water free from infection and to destroy the typhoid bacilli in all discharges that may contain them. During times of epidemics special care should be taken to boil all drinking water, to pasteurize all milk to be drunk, and to wash all vegetables to be eaten uncooked, in boiled water.

So far as the destruction of the bacilli in the discharges is concerned, the disinfection of the urine and stools is of the utmost importance. The stools are best disinfected with a 5 per cent. solution of carbolic acid. The solid parts should be broken up with a stick that can be burned or with a glass rod that can be sterilized after using, in order that all parts of the stool may come in contact with the disinfecting fluid. Stools treated in this way should be allowed to stand for at least one hour; then thrown into the closet, buried, or burned. In the country they should be thrown into a trench so placed that the surface drainage is away from the well or the nearest water course. Quicklime should cover the stool in the trench and over this dirt should be thrown. The urine should be disinfected with carbolic acid solution in the same manner. All urinals and bed-pans must be disinfected with carbolic solutions after being used.

The patient should have eating utensils and toilet articles for his own exclusive use, which should be marked and kept separate from all others. Remnants

of food should be burned or disinfected away from the kitchen.

Nurses and attendants on typhoid patients must always wash their hands after handling the patient in a 1: 1000 solution of bichloride of mercury. Uniforms and linen that have been worn in the patient's room should be soaked in carbolic solution before being taken to the laundry. Nurses should not eat in the same room with typhoid patients. The direct infection from patient to nurse is not at all uncommon, and the directions just given must be strictly observed.

After recovery the patient should be given a full bath before leaving the room, and the room itself disinfected in the usual way. Chronic carriers should be isolated and every effort made to render them non-infectious.

Immunity.—Infection with the typhoid bacillus is followed by an immunity to the disease which persists for a variable length of time, sometimes for life. Instances of reinfection are rare. The immunity is conferred by the presence in the blood of protective substances known as bacteriolysins and agglutinins. The former are very much increased after typhoid, and by experiment it can be shown that the blood of patients after recovering from typhoid has marked power to dissolve the typhoid organisms. The agglutinins possess the power of drawing the typhoid bacilli into clusters or clumps. This phenomenon is made use of in detecting the presence of typhoid fever by what is known as the Widal reaction.

The Widal Reaction.—It is made in this way: A small amount of blood is drawn into a capillary tube

from the patient's ear and allowed to clot. By clotting, the serum is separated from the blood. The object of the test is to see if the serum contains any agglutinins of typhoid bacilli. All blood contains a small amount of agglutinating substance; so the serum is diluted, say, to 1 : 20 or 1 : 40 and mixed with a fresh bouillon culture of typhoid bacilli in equal parts, which makes the final dilution 1 : 40 and 1 : 80. The mixture is now incubated for one-half hour and placed under the microscope. If

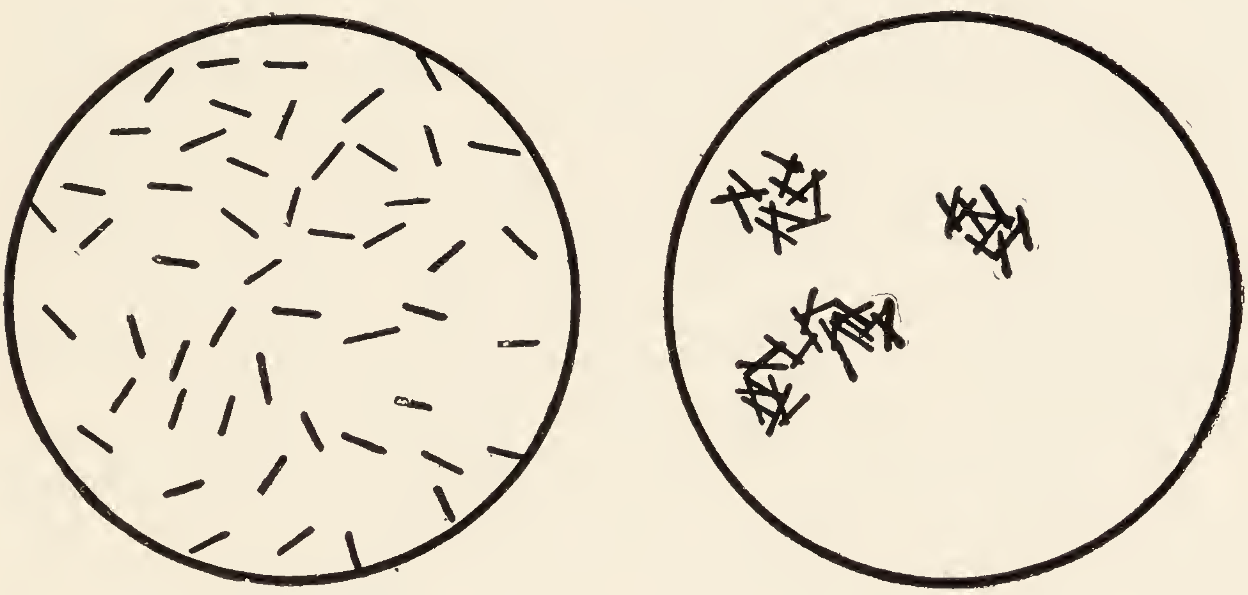


Fig. 22.—Negative and positive agglutination test.

the agglutinins are present the typhoid bacilli will be seen drawn together into clumps or clusters with loss of motility. When clumping is complete the reaction is said to be positive, and means that the patient now has or recently has had typhoid fever, or has been immunized by vaccines. Negative reactions are of no significance, as the reaction is not constant; being present some days and absent others.

Production of Immunity by Vaccines.—The prevention of typhoid has been greatly advanced by what is

known as vaccination. As mentioned earlier in the chapter, the poison of the typhoid bacilli is found within the body of the cells and is liberated only after death and disintegration of the organisms. An active immunity to the disease can be produced by injecting the killed typhoid bacilli, which after disintegration set free their poisons in the blood and stimulate the organs and tissues of the body to form protective substances that prevent infection. The inoculations consist of three injections of vaccine, the first one of 500 million, the last two of 1000 million bacilli at intervals of one week. The vaccine most used is one containing both the paratyphoid and typhoid bacilli. The inoculations are sometimes followed by a reaction marked by a rise in temperature, headache, and general malaise. This method of creating immunity to typhoid has been practised a great deal in recent years with very gratifying results.

It was first tried in this country in the United States Army maneuver camp, at San Antonio, Texas, in 1909; 8097 men were vaccinated, that is, they were injected with a killed culture of typhoid bacilli on three occasions, the dose being increased each time. Only one case of typhoid developed among these men, and this one was not fatal. In the World War, 4,000,000 men were vaccinated against typhoid, the result being that typhoid (and paratyphoid) fever to all intents and purposes did not exist even though a large proportion of the troops were on foreign soil, actively engaged in making war, and under sanitary conditions that of necessity could not be the best.

The following table gives a comparison of the number of cases of, and deaths caused by, typhoid fever,

among the United States troops during the Civil War, Spanish War, and World War.

	Number of Typhoid Cases per 1000	Deaths per 1000
Civil war	34.65	11.81
Spanish war	51.89	5.66
World war	0.37	0.06

(Major A. G. Love, The Military Surgeon, August, 1922.)

At the Samaritan Hospital Training School, Troy, New York, it has been the custom for the past ten years to immunize all nurses when they enter. It is now a routine procedure in many training schools in the United States. The immunization against typhoid among the people of the United States is on the increase, particularly in the families where someone is sick with the disease. Many people who are planning to travel abroad are being immunized. The length of the immunity conferred by the vaccine is not known, but it is said to be from two to two and a half years.

THE BACILLUS PARATYPHOSUS.

The paratyphoid bacillus in shape and size is very much like the typhoid bacillus. It is differentiated from the typhoid bacillus by its ability to ferment glucose. There are two types of paratyphoid bacilli, called types A and B, which differ slightly in their method of growth. They also behave differently in the agglutination or Widal reaction. The blood serum of the patients sick with paratyphoid fever will not agglutinate the typhoid bacillus. If the infection is due to paratyphoid A the blood will not agglutinate the paratyphoid B, but only the A.

Differential Diagnosis.—The agglutination reaction is a very good way to diagnose the type of infection present in all cases of typhoid-like infection. The organisms may be recovered, also, from the stools and from the blood, by blood culture.

Symptoms.—The course of the fever in paratyphoid infections is somewhat milder and shorter than in typhoid. The clinical picture differs in some ways from true typhoid. Vomiting and diarrhea are more prominent symptoms, and the fever has a more abrupt onset and is more irregular. In the fatal cases coming to autopsy the spleen and mesenteric glands are enlarged, just as in typhoid, but the intestines show little change. Changes in the bowel do occur because hemorrhage sometimes occurs in paratyphoid fever.

Immunity.—Immunity follows an attack of paratyphoid fever just as in true typhoid, but the protection is only against the type of paratyphoid bacillus causing the infection. A case illustrating this point came under the writer's observation in the summer of 1913, in which the patient developed typhoid-like symptoms and fever, although he had had a severe typhoid infection only a few years before. The infection proved to be a paratyphoid, type B.

In the immunization against typhoid with killed cultures it is now customary to use the killed bacilli of both typhoid and paratyphoid, in order to confer immunity to all types of typhoid-like organisms.

THE BACILLI OF THE DYSENTERY GROUP.

The first member of this group was discovered by Shiga, a Japanese, in 1897. In its size and shape it is

very much like the colon bacillus, but does not ferment sugars like the colon bacillus does. It can be grown from the surface of the large bowel or from the stools of dysenteric patients, and cultures when fed to dogs cause dysentery.

Symptoms of Dysentery.—In man the onset is acute, with nausea and vomiting, abdominal pain, and diarrhea. The stools contain mucus and smaller amounts of blood. Later there is severe colic, muscular twitching, and great prostration. The bowel at autopsy is inflamed and studded with small ulcerations. There is seldom any septicemia. The disease spreads rapidly, sometimes through infected water, sometimes from direct contact, but more often by food contaminated by flies. It lasts from seven to ten days, and frequently is attended with a death rate of from five to twenty in a hundred. It is a very serious disease in young children and debilitated persons.

Numerous epidemics have been reported in the United States; among them an epidemic of 350 cases in the village of Tuckahoe, N. Y., which was studied by the writer, together with Dr. Wm. H. Park. The cause of the epidemic was found to be due to an organism almost identical with the one described by Shiga. From a study of the dysentery bacilli found in this and other epidemics in this country, we find that there are a number of bacilli very nearly alike that may cause these epidemics of dysentery.

Individuals who have been infected with dysentery bacilli develop agglutinating substances in the blood that will clump the dysentery bacilli just as in the case of typhoid and paratyphoid infections. This fact is

made use of in the diagnosis of dysentery and is carried out in the same manner as the Widal reaction.

Prevention.—The prevention of dysentery, particularly during epidemics, requires prompt and proper disinfection of the intestinal discharges, the closure of open latrines, and the screening of kitchens, so that flies cannot contaminate the food. No one having intestinal trouble should be allowed to handle the food.

Vaccination with killed cultures has been tried in Japan with some reduction in the number of deaths. The serum of horses immunized to many types of dysentery bacilli has also been used, but the results have been uncertain.

Summary.—To summarize what has been said of the colon-typhoid-dysentery group: All the members are bacilli of similar appearance, all are to some degree motile, but they differ one from another in their growth, particularly in their ability to ferment sugars and produce acid in culture media. The colon group, although a constant inhabitant of the intestine, gives rise to no infection unless it gains access to tissues outside the bowel. The typhoid and dysentery bacilli are never present in the body under normal conditions, but when they enter the body they cause a characteristic infection. The blood-serum of all infected individuals develops substances that protect against reinfection, and among these substances are the agglutinins which gather the bacilli together into clumps. The agglutinins caused by infection with the colon bacillus will agglutinate only the colon bacillus; the same is true for the typhoid, paratyphoid, and dysentery bacilli. This

peculiarity is made use of in diagnosing the kind of infection present.

THE BACILLUS LACTIS AËROGENES.

The *Bacillus lactis aërogenes* is constantly present in milk and, with other micro-organisms, is the cause of souring. It is also present in water, sewage, and feces. It closely resembles the colon bacillus, but differs from it chiefly in being non-motile and having a capsule. It is not a virulent organism, but has been known to be the cause of cystitis, or inflammation of the urinary bladder. Here it occasionally forms gas, a condition known as pneumaturia.

THE BACILLI OF THE PROTEUS GROUP.

The members of this group are putrefactive bacteria capable of breaking down complex proteids into simpler compounds. They are widely distributed, being found in water, soil, air, and wherever putrefaction is in progress.

Bacillus Proteus Vulgaris.—The chief member of the group is the *Bacillus proteus vulgaris,* a large, thick bacillus that grows readily on the ordinary media. It is motile, but forms no spores. It liquefies gelatin in its growth and produces a characteristic odor of putrefaction. It is not a very virulent organism. It occasionally causes peritonitis, endometritis, pyelonephritis, and enteritis. It has been described as the cause of several epidemics of meat poisoning.

THE MUCOSUS CAPSULATUS GROUP.

In this group are placed a number of microorganisms which resemble one another closely in their morphology and manner of growth. The members of this group differ but little from those of the colon group.

The Bacillus Mucosus Capsulatus.—This bacillus was discovered by Friedländer in 1883, and is often called the Friedländer bacillus. It is a short, plump, bacillus, with rounded ends, exhibiting considerable variation in size. It is so short that at times it may be mistaken for a coccus. It may occur singly, in pairs, or in chains. It is not motile and forms no spores. On all the ordinary culture media it grows readily even at room temperature. The most characteristic feature is the transparent capsule about the organism. Exposure to heat of 60° C. destroys the bacillus in a short time.

At the time of its discovery this bacillus was believed to be the chief cause of lobar pneumonia, but it has since been proved that it is responsible for only 7 to 8 per cent. of the cases. Pneumonia caused by it is usually fatal. In addition to causing pneumonia, it has been found in suppuration of the nasal sinuses, empyema, pericarditis, and meningitis. It occasionally causes septicemia. No method of immunization has been found as yet.

The Bacillus of Rhinoscleroma.—This bacillus is a short, plump rod, in appearance and manner of growth almost identical with the *Bacillus mucosus capsulatus*. Infection with this micro-organism is located usually in the mucous membrane of the nose, mouth, pharynx, and larynx. It produces hard, nodular, inflammatory,

swellings. Under the microscope, large, swollen cells are found in the tissue which contains the bacilli.

Questions in Review.

1. What organisms comprise the colon, typhoid, dysentery group? Why are they grouped together?

2. What infections are caused by the colon bacillus?

3. How do the typhoid and paratyphoid bacilli differ from the colon bacillus? What is the object of the special media used to distinguish them?

4. In what organs and tissues may the typhoid bacillus be found during typhoid fever? What is the relationship between typhoid infection and gall-stone formation?

5. In what ways may a person contract typhoid fever? Upon what does typhoid immunity depend?

6. Why should the Health Bureau be informed of all cases of typhoid?

7. What is the significance of a positive Widal, a negative Widal?

8. Of what importance is the leucocyte count in typhoid infection?

9. How may active immunity to typhoid and paratyphoid fever be produced? How long does it last?

10. How may the nurse protect herself during attendance on a typhoid patient?

11. How does infection with dysentery bacilli take place?

12. What is the chief characteristic of the Friedländer bacillus? What kinds of infection does it cause?

CHAPTER XII.

BACTERIA CAUSING ACUTE INFECTIONS.

THE BACILLUS OF TETANUS.

Tetanus, or lockjaw as it is more commonly called, has existed for many centuries, but the micro-organism

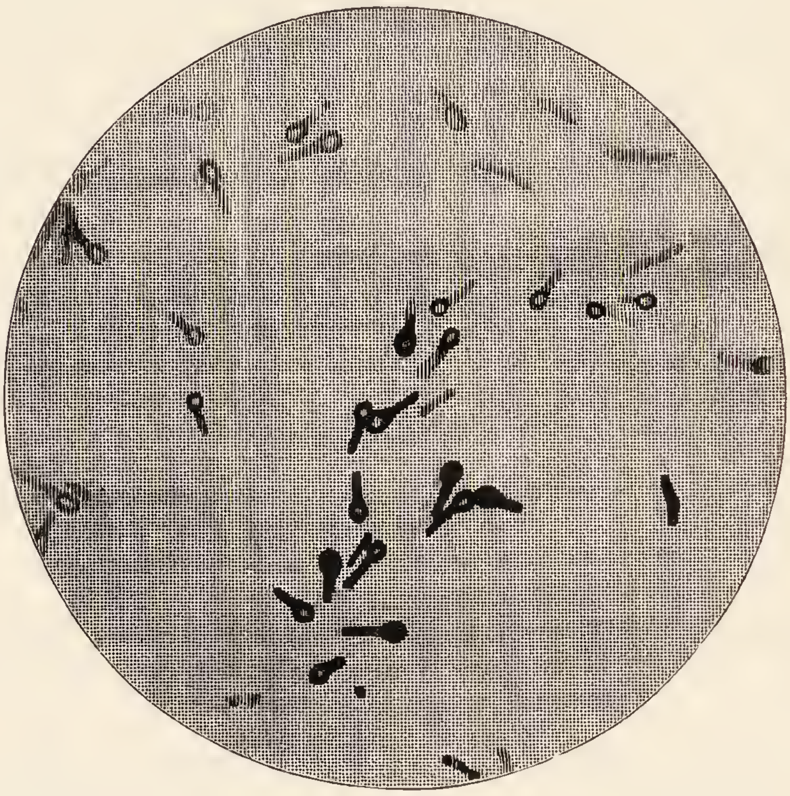


Fig. 23.—Tetanus bacilli. Spore-bearing rods from an agar culture. Mounted preparation, stained with fuchsin. × 1000. (*Fränkel-Pfeiffer.*)

causing the infection was not discovered until 1885, when Nicolaier, a German bacteriologist, was successful in producing the disease in animals by injecting them with small amounts of soil. Kitasato, a Japanese, in 1889, was the first to isolate the bacillus in pure culture, by cultivating it under anaërobic conditions.

Morphology.—The organism is a slender bacillus which forms spores readily. It has flagella and is

motile. It stains readily and is Gram-positive. It grows on the ordinary culture media, but only when no oxygen is present. The spores are located at one end of the bacillus, and cause a swelling which gives it much the same shape as a drumstick. The spores are very resistant to harmful influences. They will survive dry heat of 80° C. for an hour, and 5 per cent. carbolic acid solution for twelve to fifteen hours. Away from sunlight the spores may live for years.

Distribution.—Its natural home throughout the world is the soil, especially where it has been cultivated and manured. This is due to the fact that tetanus bacilli are present in the intestines of some animals. In the United States the soil in the Hudson Valley and on Long Island seems particularly infectious. In tropical countries, too, the organism is prevalent, occasionally causing lockjaw in the newborn.

Manner of Infection.—Infection generally occurs by the contamination of lacerated wounds, especially gunshot wounds, with particles of wood, soil, or glass. A great many cases in our country have been due to wounds caused by fire-crackers and blank-cartridge pistols, and have led to the crusade against their use on Independence Day.

There was great danger of this infection from shell wounds and compound fractures during the World War, particularly when the wounds also became infected with the common pus cocci. These seem to favor the development of the tetanus bacilli if they are present.

Course of Disease.—The period of incubation in man is from five days to four or five weeks. In general,

a short incubation period means a more severe infection. The muscular spasm generally begins in the muscles of the face and jaw, making it difficult to chew. This is the origin of the popular name, lockjaw. Gradually other muscles become tight and stiff, until finally all the muscles of the trunk and extremities are affected. The least irritation is sufficient to throw all the muscles into spasm, making the entire body rigid, the spine arched, and the body resting on the head and heels, a posture called opisthotonos.

Tetanus Toxin.—The spasms are produced by soluble poisons that are formed by the tetanus bacilli at the point of inoculation, and seem to have a special affinity for the tissues of the brain and spinal cord. They reach the central nervous system by traveling along the motor nerves from the point of entrance. The poisons are also formed in the culture media, and are among the most powerful known; the poison formed in a bouillon culture being sufficient to cause death when injected into mice in doses of 0.0000005 cubic centimeter. Man and the horse are very susceptible to the poison, while chickens are able to resist large doses.

It is possible to immunize animals against the tetanus toxin by injecting the poison in very small doses and gradually increasing it. After a time the animal can withstand large doses without ill effect. The antitoxin is made by injecting horses with ascending doses of the poison until they are thoroughly immunized; then they are bled and the serum, which contains the protective substance is used to protect human beings. Tetanus antitoxin is used both as a prophylactic and a curative agent.

Serum Treatment.—For prophylaxis a dose of 1000 units is given intramuscularly in all cases where wounds have been contaminated with dirt. In the United States Army during the war all wounded men received tetanus antitoxin at once and another dose after ten days. By this means the incidence of tetanus in the Army was practically *nil.*

For curative purposes tetanus antitoxin must be given intraspinally by lumbar puncture, because the toxin has already reached the central nervous system, in doses of 3000 to 5000 units and repeated if necessary. At the same time 10,000 units of the antitoxin should be given intravenously or into the muscles. The prospect of success in cases where tetanus has already developed is not as good as it is in prophylaxis.

Prognosis.—Recovery depends a great deal on the length of the incubation period. Cases with a short incubation are more severe and get well less often than those with an incubation period of twelve days or more. The promptness in giving the antitoxin is also an important factor. If given as soon as the symptoms develop, there is a better prospect of success. Even in late cases the antitoxin should be tried. The writer recalls one instance in which the spine was so rigid that a general anesthetic had to be given in order to make the spinal puncture. Recovery followed after four treatments.

ACUTE ANTERIOR POLIOMYELITIS.

This is an acute infectious disease affecting the gray matter of the brain and spinal cord, causing paralysis of groups of muscles. It occurs in epidemic and spor-

adic form. It affects children particularly, and while the mortality rate is low, the deformities resulting from the paralysis are very disfiguring. There is a wide variation in the severity of the infection. Mild cases may show only a temporary weakening of a single muscle group. Severe cases may die of paralysis of the respiratory center in the medulla of the brain.

Recently, Drs. Flexner and Noguchi, at the Rockefeller Institute in New York, have been successful in cultivating an organism from the spinal cords of fatal cases of this disease. The organism as described by them is an oval, globoid body arranged in pairs, short chains, or masses. These bodies were also found in the tissues of the spinal cord. By inoculating monkeys with cultures of this organism, they have reproduced the disease, and after the death of the animals, have recovered the organism from the spinal cord.

Manner of Infection.—The infection is spread by the discharges from the nose, throat, and intestines; so they should be collected and destroyed. Convalescents may carry the infection for months and act as carriers. As an added precaution the patient should be isolated.

Serum Treatment.—The treatment of the patient with the blood serum of recently recovered cases has been attended with some degree of success. The serum is introduced directly into the spinal canal by lumbar puncture. The earlier in the disease the serum is given the better is the prospect of success. This treatment seems to prevent the paralysis but has no affect on it after it has once developed.

THE BACILLUS BOTULINUS.

This bacillus is the cause of severe irritation of the stomach and intestines. Absorption of the poisons of the bacillus causes serious toxemia, called Botulismus.

Morphology.—The bacillus is large with rounded ends; they may form short chains. It is slightly motile. It stains easily and is Gram-positive. It forms spores and is anaërobic. The organism has a wide distribution but has been found most often in the intestinal contents of hogs. It has also been found on vegetables, fresh or canned, and fruits, and in the droppings from insects. In Europe infected meat has been the chief cause of the disease. Van Ermingen, 1896, the first one to describe the *Bacillus botulinus,* found it in pickled ham. The toxin formed by the bacillus is a soluble one and is found in the media on which it is grown. It is a very powerful poison and one instance is quoted by Dickson, in a publication from the Rockefeller Institute, where death resulted from eating a small spoonful of spoiled corn. The toxin is not formed, so far as is known, in the human body. It is formed in food products that cause poisoning when they are eaten.

A number of outbreaks have been reported in Europe and this country. A very serious one happened in 1919, due to infected ripe olives. The death rate has been as high as 64 per cent. in the United States.

Symptoms.—Botulinus develops quickly after eating the food containing the poison, usually within twenty-four hours. There is first general malaise and headache, followed by disturbances of vision, difficulty in swallowing, and thick speech. There is no elevation of tem-

perature. Death may follow in from three days to a week from heart failure or asphyxia.

Immunity.—Injection of the poison into animals in slowly increasing doses will immunize them. The blood serum of these animals contains an antitoxin which may be used intravenously in human beings. The antitoxin has not been used in a sufficient number of cases to say how effective it is.

To prevent Botulismus all home canned food should be cooked before being served. The appearance and taste give no warning that the food is poisonous.

THE BACILLUS WELCHII OR THE GAS BACILLUS.

This organism was discovered in 1892 by Drs. Welch and Nuttal at the Johns Hopkins Hospital. It is the chief cause of gas gangrene developing in wounds. During the World War it was found in about 80 per cent. of the gas gangrene cases.

Morphology.—It is short, grows singly or in pairs and is an anaërobe. It is Gram-positive. It has no motility and has a capsule. Spores are formed. It ferments all sugars with the formation of a large amount of gas. This is its chief characteristic.

The bacillus forms a toxin which will stimulate the formation of an antitoxin in animals. (While the *Bacillus welchii* is most often concerned in the cause of gas gangrene, there are a number of other organisms, resembling it closely, that may give rise to the same gangrenous condition; *viz.:* the *Vibrion septique,* the *Bacillus edematiens* and *Bacillus fallax.*)

Distribution.—The *Bacillus welchii* is found in the intestinal discharges of both infants and adults. Wounds

into which dirt or soiled clothing have been carried are most likely to be infected with the gas bacillus. It is a curious thing that gas bacillus infection is most likely to develop when other organisms, like the pus cocci, are present too. The gas bacillus ferments the sugar in the muscles and produces gas in the tissues so that a crackling sensation is produced when the tissue is pressed with the finger. This is also spoken of as emphysema of the tissues. Wounds in which the tissues have been lacerated, as in railway accidents and particularly gunshot or shell wounds, offer a very suitable medium for the development of the gas bacillus. It was learned during the war that this infection could be prevented or checked by the excision of such tissue, with foreign bodies, if present, followed by repeated irrigation with Dakin's solution.

Antitoxin.—An antitoxin has been prepared which is effective. It must be given as soon as possible after being injured or wounded. The serum is given intravenously. During the war the serum was used with success for the prevention of gas gangrene.

THE BACILLUS MALLEI (GLANDERS BACILLUS).

Glanders is a malady which occurs principally among horses, but dogs, cats, sheep, and swine, are also susceptible. In rare instances man acquires the disease. It is caused by the *Bacillus mallei,* a small, rod-shaped organism with rounded ends. It can be cultivated easily on the ordinary kinds of culture media, and stains readily but unevenly, giving the bacillus a granular appearance much like the bacillus of diphtheria. Heat at 60° C. will destroy the bacilli in two hours and 1 per

cent. carbolic acid solution in thirty minutes. Drying destroys them in a short time. In water they may live for two months or more.

Infection and Symptoms.—The infection in horses occurs generally in the nose or mouth, from the entrance of the bacilli through cracks or wounds in the mucous membrane. After an incubation period of two or three days there is a nasal discharge with swelling of the nasal mucous membrane, which later ulcerates. The cervical lymphatic glands also swell and may suppurate. The disease frequently terminates in pneumonia. Infection through the skin gives rise to a nodular eruption, the nodules later undergoing suppuration. This is called "farcy."

The disease may be transmitted to human beings from infected horses or may pass from man to man. The manifestations of the disease in man are much the same as in the horse. It may assume an acute or chronic course, the former nearly always resulting fatally.

The toxins of the *Bacillus mallei* are within the bodies of the organisms, that is, they are endotoxins and are very resistant to heat. Attempts have been made to immunize animals by the injection of small amounts of the toxin, and have been to some extent successful. It is not possible to immunize man in this way.

Diagnosis.—The diagnosis of glanders may be made in several ways. The discharges or the pus may be injected into the peritoneal cavity of guinea-pigs. If the bacillus of glanders is present the testicles become swollen and painful in two to five days. This is called the "Strauss test." A test may be made for the presence

of substances in the blood serum that will agglutinate the bacilli of glanders. It is done in the same manner as the Widal reaction for typhoid fever. Recently a complement fixation test has been developed for the detection of the disease. Finally, the toxin of the bacilli made from cultures and called mallein may be injected under the skin of suspected cases. If glanders is present it produces a reaction marked by fever and tenderness about the point of inoculation. The principle upon which this reaction rests is the same as in the tuberculin reaction. Recovery from glanders does not protect against subsequent infection.

The Bacillus of Influenza.

Morphology.—This organism was described by Dr. Pfeifer in 1892. He found it in the sputum of typical cases of influenza. It is a very small bacillus, aërobic, non-motile, and Gram-negative. It will not grow except on media that contains hemoglobin and so is spoken of as hemophilic. It grows best in the presence of the staphylococcus. Heat kills the bacillus readily; an exposure of a few minutes at 60° C. is sufficient. It is killed quickly by drying. It stains poorly so that it must be exposed to the ordinary stains much longer than usual. In sputum it is found in clusters in the mucus. The toxins are largely endotoxins set free when the organism disintegrates. No immunity follows infection with the influenza bacillus.

It has been isolated during the disease from the sputum, the nasal discharges, from the sinuses, and from meninges, particularly in children.

Symptoms.—Influenza or grippe is a very infectious disease affecting the nose, throat, and bronchi, and in uncomplicated cases is a mild kind of infection. It has a sudden onset with chilly sensations, followed by moderate fever, aching all over, discharge from the nose, and mild sore throat. It lasts three or four days, but is followed by prostration so marked that it is out of all proportion to the mild illness preceding it. This is the outstanding sequela of the disease. It is believed that this mild infection lowers the resistance of the patient so that he becomes susceptible to infection of the lungs, the ears, and sinuses of the nose. This is the probable explanation of the large number of pneumonias that have followed influenza. It is generally accepted as a fact that the influenza bacillus alone does not cause pneumonia. The organisms that cause pneumonia, following or complicating influenza are the hemolytic streptococcus, the pneumococcus (all types), the bacillus mucosus capsulatus (Friedländer), and the micrococcus catarrhalis.

The cause of influenza, as we know it today, is not positively known. It is probably due not to any one organism but to a group of organisms, mentioned above, acting together with the influenza bacillus. In times of epidemic the infection is probably due to the influenza bacillus alone, at the outset, but as the cases multiply in number, other organisms complicate the infection and make the disease a more serious one.

No immunity follows an attack of influenza. Active immunity has been tried by using the vaccines of the influenza bacillus but no benefit or protection resulted.

Epidemics.—Epidemics of influenza have occurred many times, according to Leichtenstern. The first one occurred in 1729 to 1733, starting in Russia and extending over Europe. Some twelve epidemics followed up to 1889 when the infection became pandemic, under the name of La Grippe. In the years following, the infection was more or less sporadic, until 1917 when the last epidemic began in Europe. It seemed to start in several localities at the same time and spread with great rapidity. It affected the American and British forces in France in the winter of 1917 and 1918 and, to some extent, the troops in training camps in this country. After an interval of seven months the infection became active and in October, 1918, was pandemic in the United States and throughout the world. It spread with appalling rapidity and was characterized by great virulence. The number of people who lost their lives was very large, estimated at 550,000 in the United States alone. Among the United States soldiers in the training camps and in France, there were 791,907 men sick with the disease, and 24,664 of them died of it, according to the statistics of Major Love of the Medical Corps of the United States Army.

Prevention.—Influenza spreads by direct and indirect contact. This is an established fact, because it never spreads more rapidly than human beings can travel. The infection is transmitted so far as it is known by the secretions of the nose and throat. People are so susceptible and the infection is so virulent that quarantine or isolation is useless. About all that can be done is to avoid, if possible, all crowds, even those of cars or busses, and to maintain the general health

and resistance on as high a plane as possible. With the first symptoms of the infection one should go to bed and remain there a day or two longer than would seem necessary, in order to avoid complications of more serious import.

Precautions.—Nurses must endeavor to protect themselves against infection by paying scrupulous attention to the disposal of sputum and nasal discharges, and to keep out of range during the patient's coughing and sneezing attacks. During the last influenza epidemic, gauze masks and throat sprays of various antiseptic solutions were used by many nurses. How much protection these measures afforded is problematical. Strict attention to personal hygiene, regular hours of exercise in the open away from crowds, and regular hours of rest and sleep, so far as is possible, are obligatory on the part of the nurse.

Nurses are always in great demand in epidemics and in the case of influenza epidemics, because of the great number of people sick, are in greater demand than at any other time. Nursing plays such an important rôle in the care of influenza patients that a heavy obligation rests upon the nurse, just as much as it does on the physician, to meet the crisis regardless of the personal inconvenience and danger involved. The service rendered by nurses in the last epidemic was remarkably efficient.

THE BACILLUS OF WHOOPING COUGH.

Morphology.—The bacillus causing whooping cough was first described by two French bacteriologists, Bordet and Gengou, in 1900. It is very small, oval, and

Gram-negative. It shows bipolar staining and resembles the bacillus of influenza in growing best on culture media in which there is blood or its coloring matter. Cultures of the bacillus may be obtained by exposing the medium on a petri dish before the mouth, during a paroxysm of coughing.

Symptoms.—After an incubation period of two weeks the infection begins like an ordinary cold but soon localizes in the throat, nose, and bronchial tubes. After a week the paroxysms of coughing begin accompanied by the characteristic whoop. This is caused by the violent effort made to draw air into the lungs after prolonged coughing. The disease may be transmitted any time during the disease and sometimes for a considerable time afterward. Most children and some adults are susceptible and contract the disease by contact. The disease occurs in epidemic form and seems associated with epidemics of measles. One attack generally protects during life; so cases of reinfection are very rare.

Toxins.—The toxins of the bacillus are within the bodies of the bacterial cells (endotoxins). Efforts have been made to immunize against the disease by injecting the killed bacteria. This should be tried, as the results have been fairly satisfactory. Vaccines have also been used in treatment but the results have not been particularly good. Whooping cough is a serious disease among children. It is reckoned one of the major causes of death in this country. It is particularly fatal, due to lung complications, in children under three years. Children with the disease must be excluded from school

and isolated from other children for several weeks after the cough has stopped.

THE KOCH-WEEKS BACILLUS.

Pink Eye.—This organism is the cause of acute infectious conjunctivitis commonly called "pink eye." It resembles closely the bacillus of influenza, but differs from it in growing on media that does not contain hemoglobin.

THE DUCREY BACILLUS.

This bacillus is of very small size, and has a tendency to form chains. It is not motile and does not form spores. It stains with all the ordinary dyes, but more deeply at the ends. It will grow only on media containing human blood. Infection with this organism is the cause of chancroid, or soft chancre, an acute, inflammatory, ulcerating sore which occurs generally on the genitals and surrounding skin. It begins as a small pustule which ruptures and becomes an ulcer, having a tendency to spread. The sores are often multiple. Occasionally the ulcers become very large and destructive. The incubation period is short—two or three days, and the ulcerations are very slow to heal. The bacilli frequently extend along the lymphatic vessels and involve the adjacent glands of the groin, which may undergo suppuration. These are called buboes. The bacilli can be found in the pus and discharges from the ulcers. Infection results generally from sexual contact, rarely from infected dressings, towels, and instruments.

THE BACILLUS MELITENSIS, THE BACILLUS ABORTUS.

These organisms are grouped together because of the similarity in their appearance under the microscope and their growth on culture media. They are identified chiefly by agglutination tests.

Bacillus Melitensis.

The *Bacillus melitensis* was first described by Bruce in 1887, and the group is referred to as the Brucella. Malta fever, or undulant fever, is caused by the *Bacillus melitensis.* It is endemic among the people living on the shores of the Mediterranean and occurs to a lesser extent in Spain, Italy, France, Northern Africa, and the Balkans.

Morphology.—The organism is very small, non-motile, and Gram-negative. It can be grown on the ordinary culture media at body temperature. It may be recovered from the circulating blood of patients sick with the disease, and also from the urine. The infection comes from the milk of goats which are infected. As goat's milk is largely used along the Mediterranean this is the chief source of infection.

Symptoms.—The disease is much like typhoid fever in the symptoms produced except that the fever is undulating or wave-like. There are periods of rather high fever alternating with periods of low fever. The periods of fever last from one to three weeks; the remissions one or two days. This condition may last many weeks or months. Occasionally it is very severe and may be fatal in a week but as a rule very few deaths result.

Diagnosis.—The diagnosis is made either by agglutination tests, using the blood serum of the patient with cultures of the *Bacillus melitensis,* or by culturing the organism from the blood. Inasmuch as the infection is transmitted in goat's milk, pasteurization of the milk will prevent the disease. Children traveling in these countries who must have milk should be protected in this manner. Carriers may transmit the infection; and possibly, flies and mosquitoes, by contaminating food. An immunity of variable duration develops after recovery. Vaccination with killed cultures has been tried, but not in a sufficient number of cases to form a decisive opinion as yet.

Abortus.

The *Bacillus abortus* is the organism producing an infection in cattle and causing abortion in cows. It may occur in cows that have not aborted and are carriers of the infection. It is so much like the bacillus of Malta fever that it can be distinguished from it only by agglutination tests.

Infection and Symptoms.—The bacillus finds its way into the milk of infected cows, and in this way the infection of human beings takes place. It gives rise to a protracted undulant type of fever, periods of moderately high fever much like typhoid, with remissions of short duration.

In addition to the fever there may be headache, malaise, prostration, and anemia. There has been a large number of these cases reported in the United States in the last few years. Whether this is due to a better understanding of the disease or an actual increase

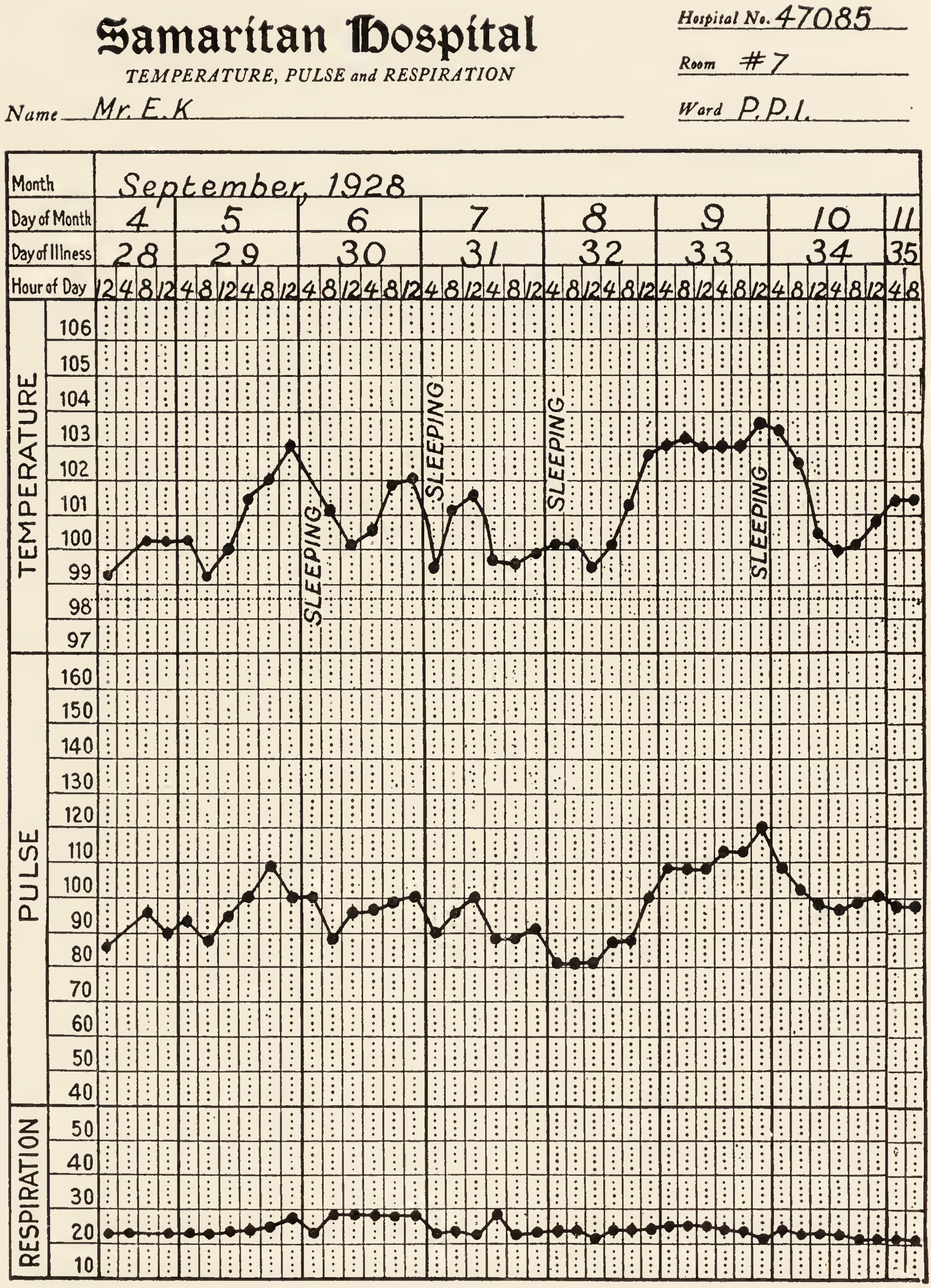


Fig. 24.—Temperature chart showing the undulant type of fever in *B. abortus* infection.

in the number of people infected is not entirely clear. At any rate, the disease is a serious one, not so much from the loss of life it may cause as from the long period of time over which it extends.

Diagnosis.—The diagnosis of the disease is made by agglutination tests, using the patient's serum in varying dilutions with broth cultures of the *Bacillus abortus,* after the manner of the Widal test. The organism may also be cultivated from the circulating blood and the urine in some cases, but it is a difficult procedure. Guinea pig inoculation with suspected milk or urine may be undertaken but it requires eight to ten weeks for the infection to become manifest in the organs of the animal. When they do occur they look like the nodules of tuberculosis.

Immunity.—Whether immunity follows this infection is not known positively as yet, but presumably it does, just as in Malta fever. Infection may be prevented by pasteurization of the milk or in boiling of milk, as practiced in some of the European countries.

THE BACILLUS PYOCYANEUS.

Morphology.—The discharges from open wounds occasionally have a green color, the cause of the color in these cases being due to a pigment formed by the *Bacillus pyocyaneus.* It is a short, actively motile rod, Gram-negative, having a tendency to form chains in fluid media. It can be readily cultivated in the presence of oxygen, and is easily identified because it stains the media upon which it grows a brilliant green. It forms no spores.

This organism possesses no great virulence, and may live without producing injury on the skin, and in the respiratory and intestinal tracts of animals and man. It may, however, be the cause of otitis media and diarrhea and gastroenteritis in children. Cases of general sepsis, liver abscess, and pericarditis have been attributed to it.

The pigment produced is of two kinds; one is called pyocyanin, soluble in chloroform; the other is a fluorescent pigment soluble in water. In old cultures, a ferment-like substance is formed called pyocyanase, which has the property of dissolving some of the other forms of bacteria. It has been used to destroy diphtheria bacilli that persist in the throat after recovery. The toxins formed by the bacillus are both endo- and extra- cellular. Immunity in animals is produced with much difficulty, but in man no way of producing immunity has been devised.

Agranulocytic Angina.—Quite recently the B. pyocyaneus has been cultivated from ulcerations of the gums, pharynx, tongue, and larynx. Jaundice has occurred in many of the cases. The condition has been rapidly fatal. In addition to the *Bacillus pyocyaneus,* fusiform bacilli and spirilla, like those of Vincent's angina, have been found. A peculiarity of the disease is in the marked blood changes. The red blood cells are not affected, but the leucocytes have been reduced from the normal of 10,000 to 1000 per cubic millimeter or even less. The reduction seems to be confined to the granular type of leucocytes. For this reason the condition has been named agranulocytic angina.

Questions in Review.

1. Name three characteristics of the tetanus bacillus?

2. Where is it found in nature? How does it gain entrance to the body to cause infection?

3. What symptoms does it cause? How may they be explained?

4. How is tetanus antitoxin made? How is it given?

5. Where is the infection located in anterior poliomyelitis? What is usually the cause of death in poliomyelitis?

6. How is the infection spread? What precautions should be taken?

7. What serum treatment may be used? How is it given?

8. What are the symptoms in Botulism? What is the cause of the symptoms?

9. What is the distribution of the *Bacillus botulinus?*

10. What precautions should be taken to prevent botulismus?

11. What is the characteristic feature of infection with the gas bacillus? How does the infection take place? What causes the formation of gas in the tissues?

12. How does human infection with glanders occur? How may the diagnosis be made?

13. What is the rôle of the influenza bacillus in the causation of influenza?

14. What other organisms are generally associated with the influenza bacillus?

15. What is the chief cause of death in influenza?

16. What precautions should be taken to avoid the infection during times of epidemic?

17. How may cultures of the bacillus of whooping-cough be obtained?

18. To what is death during whooping-cough usually due? What is the cause of the "whoop"?

19. What is the value of vaccines in the prevention and treatment of whooping-cough?

20. What infection is caused by the Ducrey bacillus? What is the chief complication?

21. In what way chiefly is infection with the *Bacillus melitensis* and the *Bacillus abortus* spread? How may it be prevented?

22. What are the symptoms produced? How is the diagnosis made?

23. What is the chief characteristic of the *Bacillus pyocyaneus?*

24. What is agranulocytic angina?

CHAPTER XIII.

BACTERIA CAUSING ACUTE INFECTIONS
(*Continued.*)

THE BACILLUS OF ANTHRAX.

Anthrax is primarily a disease of cattle and sheep, although horses, dogs, and goats are susceptible. The

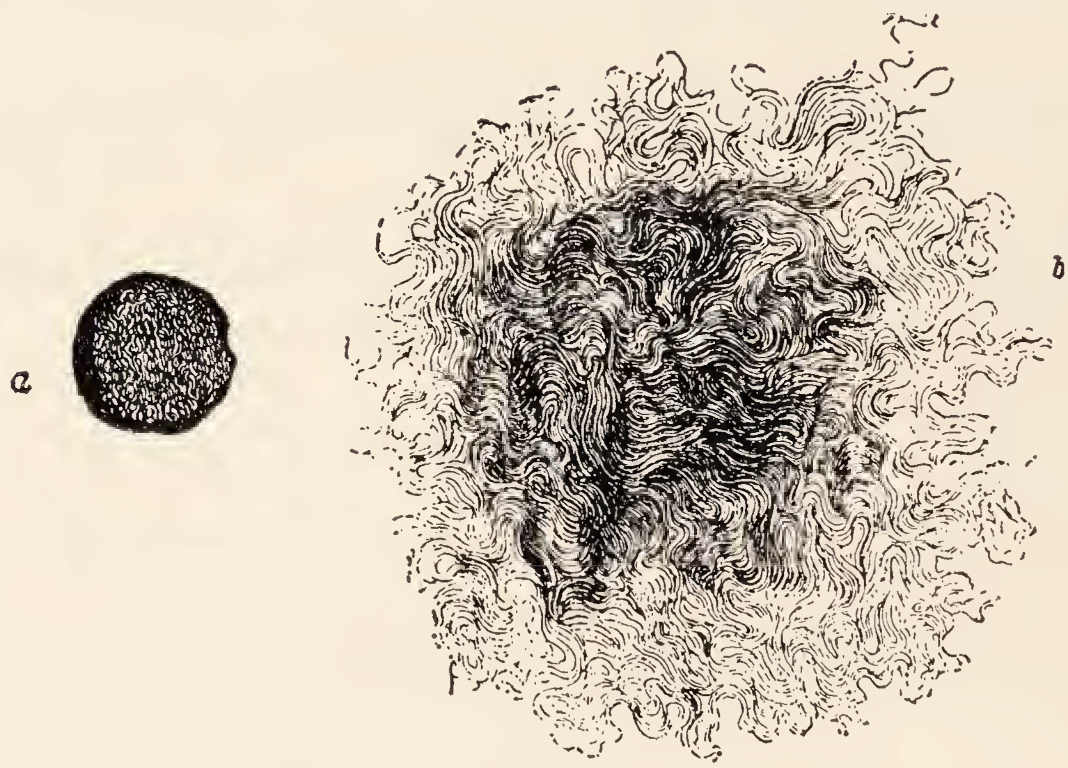


Fig. 25.—Colonies of *Bacillus anthrax.* × 80. *a,* at the end of twenty-four hours; *b,* at the end of forty-eight hours. (Park and Williams, after *Flügge.* Lea & Febiger.)

infection is usually transmitted directly to man from infected hides or wool. The disease has existed chiefly in Europe until recently. During the training of the Army, both in this country and in England, numerous infections occurred from the use of infected shaving brushes. On account of the great demand for shaving brushes by the army, bristles were imported from China

which were not properly disinfected. Anthrax bacilli were isolated from the brushes in several instances. One such instance came under our observation in 1918.

Morphology.—The anthrax bacillus was the first microorganism definitely proved to be the cause of a specific disease by Davaine in 1863. It is a large,

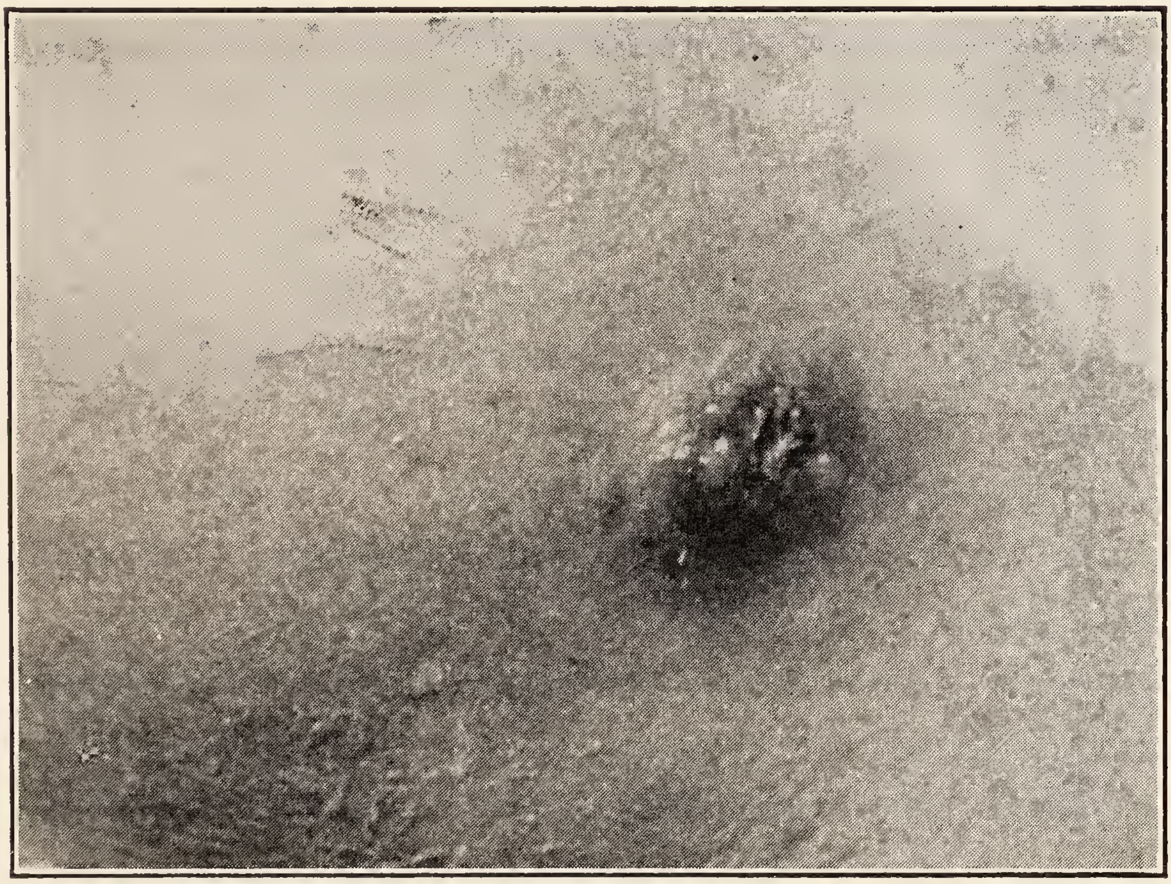


Fig. 26.—Malignant pustule due to infection from shaving brush. Author's case.

straight rod with square cut ends, and is non-motile, stains by Gram's method and forms spores. It is aërobic (Fig. 25). Its growth is characteristic. On solid culture media the colonies are composed of tangled strands which give them the appearance of a dishevelled mass of hair, and in fluid media they grow in long strings. The spores are extremely resistant and retain their vitality for years.

Infection.—In animals the infection is usually intestinal or cutaneous. In man the cutaneous infection is in the form of a malignant pustule or malignant edema. The malignant pustule is characterized by a circumscribed swelling, with edema and a black central eschar. It is frequently surrounded by a ring of vesicles (Fig. 26).

The malignant edema frequently affects the eyelids, lips, and tissues of the neck and chest. It frequently results in gangrene. Anthrax septicemia often follows the cutaneous infections.

Intestinal infection is known to occur from the use of infected meat or milk. Several instances of anthrax meningitis have been recently reported.

A pneumonic form of anthrax, known as woolsorter's disease, occurs from the breathing in of spores from dust.

Immunity.—Among animals immunity may be conferred, after the method of Pasteur, by the injection of attenuated anthrax bacilli. After animals have been immunized, their blood serum may be used to confer passive immunity. This is known as Sclavo's serum and may be used to protect against infection and in the treatment of those already infected. It is given intravenously.

THE BACILLUS PESTIS.

(Bacillus of Bubonic Plague).

Morphology.—The bacillus of bubonic plague was discovered by both Kitasato and Yersin, independently, during the epidemic in China in 1893. It is a short, thick, Gram-negative, bacillus, with rounded ends.

In old cultures, atypical forms are found, some like cocci, others club-shaped like the diphtheria bacillus. It is not motile and does not form spores. It will grow only in the presence of oxygen. It stains irregularly, due to rapid degenerative changes. In dark, moist, places the organism will live for months or years. In the sputum and pus from patients it lives for one or two weeks. In cadavers it may live for several weeks. Dry heat destroys the bacillus in one hour, boiling in a few minutes. Direct sunlight requires four or five hours. Carbolic acid (5 per cent.) and bichloride of mercury (1 : 1000) destroy them in ten minutes. It is pathogenic for all laboratory animals and particularly for rats.

Epidemics.—The plague raged from the sixth to the seventeenth century, and in the fourteenth century the black death, as it was called, destroyed one-quarter of the population of Europe. The great plague in London in 1665 destroyed 70,000 people. The disease subsided then and remained practically dormant until 1894, when it broke out in Hong Kong. It spread thence to other countries and a small epidemic occurred in San Francisco in 1907. In India the disease is endemic, and from 1896 to 1911 it caused death in five and a half million people. In Manchuria, the epidemic in the winter of 1910 and 1911 caused 45,000 deaths in a few months.

Infection and Symptoms.—The infection may enter through the skin by bites of the rat flea or by way of the respiratory tract. The symptoms of the disease manifest themselves after an incubation period of three to seven days, and may be very mild, with a few days

of fever and some swellings in the groin. These are the ambulant cases and are very dangerous to others, because they harbor the bacilli in the urine and feces. In the more severe cases there is headache, high fever, stiffness in the limbs, restlessness, and anxiety. Collapse frequently follows. The lymphatic glands, particularly those in the inguinal region, are enlarged, and are called buboes. In the most virulent infections, the onset is with severe septicemia; death comes in three or four days. Infection by way of the respiratory tract begins abruptly with pneumonia. The mortality rate for this disease is very high, 80 to 90 per cent.

The Way the Disease is Spread.—The bacilli of the plague are present in the swollen lymphatic glands, the sputum, urine, and intestinal discharges, and the infection may be spread directly from these sources. The chief way, however, in which the infection is spread is from the bites of the rat-flea, which transmits the disease from rat to rat and from rat to man. Bed bugs may also transmit it. Unsanitary conditions have little to do with the occurrence of the plague, except that they favor infestation with rats and vermin.

Ways of Prevention.—To prevent the disease from spreading, all patients must be quarantined, all discharges destroyed, and all articles that have come in contact with the patient disinfected. To prevent rats from breeding, all stables and outhouses should be cleaned up, and all possible sources of food-supply for rats, cut off. Dwelling houses should be made rat-proof as far as possible. Ports not infected should be guarded against the importation of the disease by fumigating ships from infected countries and the isolation of sus-

pected cases during the period of incubation. Particular care must be directed to the extermination of rats on such ships, for there is danger of plague wherever rats are found. Attention must also be directed to flea extermination not only on rats but on domestic animals as well.

Toxins and Immunity.—The toxins of the *Bacillus pestis* are endotoxins. It is possible to immunize animals and, in their blood, substances that will agglutinate the bacilli are found. They may be used in the diagnosis of the disease. In human beings an immunity develops after one attack. A vaccine devised by Haffkine, made from killed cultures of *Bacillus pestis,* has been used on a large scale in India by the British government. It confers a high degree of protection against the disease, and is said to reduce the mortality rate 20 to 25 per cent.

TULAREMIA.

This disease occurs among ground squirrels in California, causing an illness similar to that of plague. A bacillus, supposed to be the cause, was discovered by Drs. McCoy and Chapin. It is very small and often encapsulated and is called the *Bacillus tularense.*

So far all the cases have been found in the United States, particularly in the western and central states. It is transmitted by insects, the deer fly, the woodtick, and probably the stable fly, and squirrel flea. Beside the ground squirrel the disease also affects rabbits. Instances of human infection from rabbits have been frequently reported of late, particularly in men who are handling and dressing rabbits sent to market.

Symptoms.—In man it causes a glandular type of infection with local inflammation at the point of inoculation, swelling and redness over the glands near by. This may be followed by suppuration.

Another type closely resembles typhoid fever, with irregular fever lasting two or three weeks. The disease is not often fatal. The diagnosis can be made by agglutination tests. It is not contagious.

THE SPIRILLUM OF ASIATIC CHOLERA.

Morphology.—The microorganism causing cholera is a small, curved rod, often shaped like a comma, and therefore called the "comma bacillus," although it is a spirillum. When two are placed end to end they are S-shaped. True corkscrew forms occur, particularly in cultures in fluid media. The spirillum was discovered by Professor Koch, in 1884, who studied the disease for the German Government. It is motile, being propelled by a single flagellum placed at one end, and grows on all the laboratory media in the presence of oxygen. No spores are formed. It is Gram-negative.

Distribution of the Disease.—Cholera exists constantly in India and countries of the Orient. It has been carried occasionally to other countries, causing epidemics. A very bad epidemic occurred in Hamburg in 1892. In this country the disease has been imported on several occasions, but no epidemic has developed since 1873. Strict measures are taken at the chief ports, New York, New Orleans, Boston, Baltimore, and San Francisco, to quarantine all suspects among the immigrants.

Path of Infection.—Infection always takes place by way of the alimentary tract, from infected water and food. While infected water is the most common cause, the infection may be carried on vegetables that have been washed in infected water, particularly those used as salads. Flies can deposit the infection on bread,

Fig. 27.—Cholera spirilla. (Zinsser, after *Fränkel* and *Pfeiffer*. D. Appleton & Co.)

butter, meat, and other foodstuffs. Direct infection from handling soiled bed-linen is not uncommon, as is shown by the greater frequency of the disease among washerwomen, during epidemics.

Symptoms.—The onset of cholera, following an incubation period of two to five days is sudden, with frequent watery stools, high fever, and great prostration. In the severe cases death may occur in eight to twelve hours. The infection localizes itself in the intestine.

The spirilla are never found in the circulating blood, consequently the stools alone are infectious and may continue to be for months after recovery. People who carry the spirilla of cholera in the intestine after recovery are called cholera carriers. They may harbor the spirillum in the gall-bladder for long periods and are capable of transmitting the infection to others.

Prevention.—To prevent the disease during epidemics all drinking water and milk must be boiled, and no meat or vegetables eaten unless cooked. Great care must be taken to exclude flies from contact with foods. Bed-linen, clothing, and utensils used by patients should be soaked in 5 per cent. carbolic solution, and subsequently boiled in the laundry. Attendants upon cholera patients should be careful to disinfect the hands after handling the patients. The stools are best disinfected with 5 per cent. carbolic solution, and the disinfection should be continued for some time after recovery. The stools should be examined for the presence of the spirilla of cholera. The patient should be isolated until they have disappeared.

Immunity.—The constitutional symptoms that accompany cholera are due to the toxins formed by the spirilla in the intestines. They are found in the body of the bacterial cells and set free only after their death. It is possible to immunize animals against cholera by injecting small amounts of the killed culture or very small doses of the living organisms. The blood-serum of animals immunized in this way contains substances that dissolve the spirilla—bacteriolysins, and substances that clump them—agglutinins. The agglutinins are made use of in diagnosing cholera in the same way as in

the diagnosis of typhoid fever (see Widal Reaction). Human beings that have recovered from cholera are immune to the disease. Efforts to protect human beings by injecting the killed cultures have been made in India on a large scale by Haffkine with marked success. It must be repeated every two years.

THE BACILLUS OF DIPHTHERIA.

Diphtheria is an infectious disease caused by the diphtheria bacillus, sometimes called the Klebs-Löffler bacillus, after the two men who discovered it. The word diphtheria is derived from a Greek word meaning a membrane, because of the characteristic false membrane that forms in the throat. The bacillus causes infection most frequently in the throat or nose, although it may grow on the gums or about the teeth. It is possible for diphtheria bacilli to cause infection of the middle ear, the sinuses of the nose, and the lung (bronchopneumonia). Rarely it extends to the skin about the mouth, or to the genitalia or rectum. It may affect the conjunctiva of the eye, where it is likely to destroy vision.

Morphology.—The diphtheria bacillus has characteristic shapes quite different from other bacteria, which helps a great deal in recognizing it. Three fairly distinct forms are recognized in stained smears.

A. The granular type: The granules generally at the ends.

B. The barred type: The granules so arranged that the cell looks cross-striped like a barber's pole.

C. The solid type: With ends often club-shaped.

All these forms may be present in the same culture and represent stages of degeneration. They will grow

on most of the laboratory media, but thrive best on media that contains blood-serum. It stains readily with dyes, is not motile, and forms no spores. It is Gram-positive. Outside the body direct sunlight kills the bacilli in half an hour, but in the dust they will live for

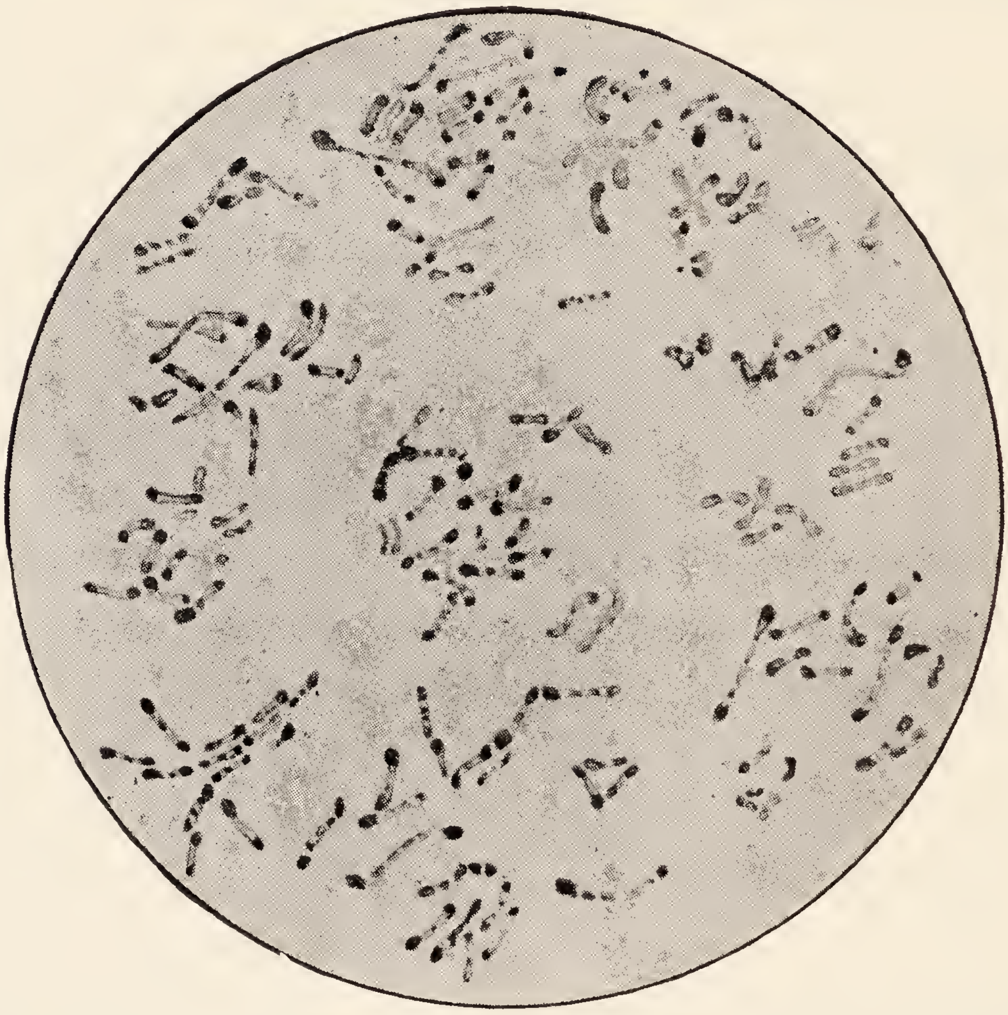


Fig. 28.—The *Bacillus diphtheriæ*. Showing variations in shape. × 1000. (Drawing by *E. L. Oatman, M.D.*)

months. On slate-pencils, cups, glasses, or toys, such as children put in their mouths, they will live for weeks.

Effects of the Disease.—In the nose and throat the bacilli cause, by the poison made by them, a death or necrosis of the mucous membrane. The membrane may extend into the nose and larynx causing an obstruction to breathing. Intubation or tracheotomy has to be done when this occurs. By far the greater damage

is caused by the poisons that are absorbed and affect the various organs and tissues, particularly the muscles of the heart, the kidneys, the adrenal glands, and the nervous system. The effect of the poisons upon the heart results sometimes in sudden death, following even slight exertion like sitting up in bed. Nurses should not allow patients to exert themselves for this reason. Paralysis may follow diphtheria when the nervous system has been attacked.

Diagnosis.—Diphtheria in the throat and nose is detected by finding the bacilli in the wipings made from the membrane. It is not safe to rely solely upon the presence and appearance of a membrane, because such membranes may be due to infection with microorganisms other than the diphtheria bacilli, such as the staphylococcus and streptococcus. In order to say whether a membrane is due to diphtheria or not, a sterile cotton swab is rubbed over the membrane, and then rubbed on the surface of a tube containing coagulated blood-serum. The tube and swab are now sent to the laboratory and incubated at body temperature from twelve to twenty-four hours in order to allow the bacteria present to multiply. The growth is now smeared on glass slides, stained with Löffler's methylene blue solution, and examined under the microscope. If diphtheria bacilli are present they can be readily identified by their appearance.

Spread of the Disease.—The disease is spread to others chiefly by means of the bacilli thrown from the nose or mouth by coughing and sneezing. The sputum contains the bacilli in large number. Indirectly, the disease is spread from the sputum by means of drinking-

cups, handkerchiefs, door-knobs, and among children from pencils, chewing gum, toys, and other things that are handled and passed about. Cats, rats, and mice may carry the infection, and flies may deposit it on food and in milk. Infected milk has been the cause of a number of epidemics.

Precautions.—The most important and first precaution to be taken in limiting the spread of diphtheria is isolation. This means the complete isolation of the sick person. The length of the isolation cannot be determined by the condition of the patient or by the appearance of the throat, because it is possible and frequently is so, that although the patient is apparently well and the throat clear, the bacilli of diphtheria are still there. In order to tell when the bacilli have disappeared a wiping of the throat is made just as described in making the diagnosis, incubated, and examined. Two such cultures free from diphtheria bacilli are considered sufficient evidence that the patient is no longer able to transmit the disease to others.

In Regard to Carriers.—In some cases virulent bacilli persist in the throat for months. Even in healthy persons, particularly attendants upon diphtheria patients, the bacilli may be carried in the throat for long periods of time without causing any of the symptoms of the disease. These diphtheria carriers may be the starting point of epidemics if they are not detected. The writer traced a serious outbreak in an orphan asylum to an apparently healthy boy, who was a carrier, whose duty it was to carry food from the kitchen to the children. Carriers are particularly dangerous when employed in the preparation of food.

Disinfection.—All discharges from the nose and mouth should be collected on paper napkins and burned. A paper napkin should be held over the nose and mouth while coughing or sneezing. All bed-linen and utensils used by the patient should be soaked in a 5 per cent. solution of carbolic acid and boiled. The sickroom must be fumigated and cleansed after the manner described under disinfection. All well persons, including the nurse, should receive an immunizing dose of antitoxin.

Serum Treatment.—The curative property of antitoxin was discovered by von Behring in 1894. By the use of antitoxin the fatal cases have been reduced 75 per cent. The antitoxin should be given in all suspected cases and in large amount. In urgent cases it may be given directly into the veins, but under ordinary circumstances it is given into the muscles. The greatest effect is attained with a large first dose, for as the disease progresses the toxin unites with the cells and is then unaffected by the antitoxin. The immunizing dose protects from two to six weeks.

Serum Sickness.—Occasionally the injection of antitoxin is followed after a few days by a feeling of malaise, skin eruption, vomiting, albuminuria, and swelling of the lymphatic glands. This condition is due to an increased susceptibility on the part of the patient to certain constituents of the antitoxin, probably the horse-serum. A few cases of sudden death following the injection of diphtheria antitoxin have been attributed to anaphylaxis, but with the precautions outlined under the subject of hypersusceptibility such accidents no longer occur.

Prevention.—Great advances have been made in the prevention of diphtheria in the last few years, so that from being one of the most common infections year after year, it has become very infrequent. Among adults the disease has never been frequent, due to the fact that about 90 per cent. are immune. Most of the preventive measures have been focused on the children, about 63 per cent. being susceptible.

Schick Test.—In epidemics the Schick test gives information which is of the greatest value in checking the spread of the disease. It is well known that a considerable number of people are normally immune to diphtheria. If a minute quantity of diphtheria toxin is injected into the skin of such people no effect is produced while in those not immune a local reaction results in twenty-four hours which is characterized by an area of redness and infiltration one-half to one inch in diameter.

Immunity.—The active immunization of susceptibles, as found by the Schick test, can be accomplished by the toxin-antitoxin mixture. This method of active immunization depends upon the injection of diphtheria toxin that has been over-neutralized by antitoxin. Much of the credit for this method is due to Dr. William H. Park of the New York City Department of Health. Three injections of the mixture are given at intervals of seven days. The reactions produced in children are very mild, slightly more severe in adults. Immunity as shown by negative Schick tests develops in about twelve weeks and persists over a period of seven years. Some idea of the success of this method may be gained from the figures given by Dr. Park. One hundred thousand

Fig. 29.—The Schick reaction in diphtheria. Typical positive reaction 48 hours after test. Strongly positive reaction, with vesiculation of the surface layer of the epithelium, which is seen occasionally in individuals who have practically no antitoxin. (Zingher, *"American Journal of Diseases of Children,"* April, 1916.)

children were Schick tested and immunized when found susceptible. Another hundred thousand were used for controls. There were a fifth as many cases of diphtheria in the first group as in the second, or control group. Since these figures were issued by Dr. Park the toxin-antitoxin procedure has been adopted by the New York State Department of Health and a crusade for diphtheria immunization has been carried on. Health Bureaus throughout the State have endeavored to immunize all school children and children of pre-school age, even as young as nine months of age. The results of this campaign cannot be stated completely but it may be said that the death rate from the disease has shown a remarkable reduction. In one city, Auburn, N. Y., there has been no death from 1924 to 1927.

In Troy, immunization of the school children was begun in 1924 and has continued each year since. In 1928 it was extended to include children of pre-school age. The following table gives the results.

	Number of Cases.	*Deaths.*
1924	315	19
1925	118	10
1926	27	2
1927	18	0
1928	12	1

With the means of prevention in hand and the intelligent application of them, it is within the power of any community to reduce the incidence and loss of life from diphtheria to a point where it can no longer be a menace to the public health.

Questions in Review.

1. What are some of the characteristics of the anthrax bacillus?

2. How may infection with anthrax take place?

3. How does anthrax infection manifest itself in man?

4. What is Sclavo's serum?

5. Where is plague endemic? Where have serious epidemics occurred?

6. How is the infection spread? Why are mild cases particularly dangerous?

7. Why is it called Bubonic Plague? What symptoms accompany the infection?

8. What means are used to prevent the spread of this disease?

9. How may immunity be established?

10. How is the infection in tularemia transmitted?

11. What are the symptoms?

12. How can the diagnosis be made?

13. Where is cholera endemic?

14. How is infection transmitted?

15. What are the symptoms of cholera?

16. What measures should be taken to prevent the infection?

17. Upon what does the immunity following cholera depend?

18. Where may the infection in diphtheria be located?

19. What are the chief characteristics of the diphtheria bacillus?

20. What are the symptoms? To what are they due?

21. What are the sequelæ of the infection?

22. How is the diagnosis made?

23. How is the infection spread?

24. Explain the rôle of carriers in diphtheria.

25. How is diphtheria antitoxin made? Does it produce active or passive immunity?

26. How does serum sickness after antitoxin manifest itself? How is anaphylaxis produced?

27. What is the principle of the Schick test?

28. How long does immunity following toxin-antitoxin injections last?

29. Why is it advisable to immunize children of pre-school age as well as children attending school?

CHAPTER XIV.

THE TUBERCLE BACILLUS AND THE BACILLUS OF LEPROSY.

THE TUBERCLE BACILLUS.

Tuberculosis is an infectious disease caused by the tubercle bacillus, which was discovered by Professor Koch in 1882. The organism is widely distributed over the world, and is pathogenic for the lower animals as well as for man. It is frequently found in cattle, less often in goats and swine, rarely in sheep, horses, dogs, and cats.

Morphology.—The bacillus is a slender rod, slightly curved, with rounded ends. It is purely parasitic, that is, it will not grow or multiply outside a host. It is never found, save in the bodies and discharges of animals affected by the disease, or in the dust or upon articles which the discharges have contaminated. It is not motile, does not form spores, and is cultivated on artificial culture media with difficulty. It cannot grow without a liberal supply of oxygen, and only at body temperature. It is killed by moist heat at 70° C. in ten minutes, but dry heat at 100° C., requires one hour. Direct sunlight destroys the bacilli in two hours, but when protected from sunlight they can live for a year.

There are four kinds of tubercle bacilli: The human; the bovine, chiefly found in cattle; the avian, found in birds; and the reptilian. The human tubercle bacillus is only slightly infectious for cattle, but the bovine

bacillus is infectious for human beings, particularly young children, who may become infected from the milk of tuberculous cattle.

Staining. — The tubercle bacillus does not stain readily, but once stained it is difficult to decolorize it with acids. For this reason it is said to be acid-fast. The method employed in staining is as follows: The suspected material is spread thinly on a glass slide and fixed. The preparation is then covered with fuchsin, a red dye to which has been added a small amount of carbolic acid solution and steamed, the heat quickening the staining. Then the preparation is washed off in water and decolorized with a 5 per cent. solution of nitric acid. This is allowed to act until all the red color is removed. After washing again in water the preparation is again stained with a methylene-blue solution. The picture produced by this method shows the tubercle bacilli unaffected by the acid decolorizer are stained red, while all other organisms are stained blue. In this way the tubercle bacillus may be detected in discharges from suspected cases.

Tubercle Bacilli in Urine, etc.—In collecting urine for examination for tubercle bacilli it is important to know that the smegma bacillus, a non-pathogenic organism found in the secretions about the genitalia, possesses the same staining peculiarities as the tubercle bacillus; so that great care must be used to exclude it from the urine by careful cleansing of the external genitalia and collection of the urine by catheter. In fluids like urine, pleural effusions, and ascitic fluid, the number of tubercle bacilli is always small; so, to detect them the inoculation of guinea-pigs with the fluid is often prac-

tised. If tubercle bacilli are present in the fluid injected, the disease develops in the animal after a period of three to six weeks. In tuberculous meningitis the spinal fluid is often clear and the tubercle bacilli hard to find. If, however, the fluid is allowed to stand ten to twelve hours a film or clot forms in which the tubercle bacilli can be found.

Path of Infection.—The tubercle bacillus may cause infection by entering the body in the following ways:

Hereditary.—Hereditary transmission, long believed to be a common occurrence, has not been proven among human beings. In very rare instances the bacilli may pass from the mother to the child in the uterus, but this depends upon some injury or disease of the placenta.

Respiratory.—This is the most common way that infection takes place. The sputum of consumptives is the direct carrier of the infection. Deposited on floors in houses, and on the streets, either by coughing or carelessness in collecting sputum, the bacilli become incorporated with the dust which is breathed in by those in close contact with the patients.

Intestinal.—This is more common in children than in adults. The bacilli gain entrance through the milk from tuberculous cattle, or food infected by consumptive people. The habit children have of putting everything into their mouths is responsible for many infections, particularly in houses where consumptives are living. The bacilli resist the action of the acid in the stomach, but in the intestine may penetrate the wall and lodge in the mesenteric glands. From this point they may be carried to remote tissues or organs.

Cutaneous.—The bacilli may enter the skin through injuries or abrasions, giving rise to the disease known as lupus vulgaris.

Tubercles.—Once in the body, the tubercle bacilli may become localized in any tissue or organ, and there proceed to multiply. The result is the formation of a nodule or tubercle, from which the disease takes its name. The tubercles are about the size of a millet-seed, and at first are distributed separately in an organ. As they grow larger the central portion is poorly supplied with blood, so that it degenerates, softens, becomes cheesy, and finally may ulcerate. Tubercles that are placed close together may coalesce and go on to ulceration, causing large abscesses. If the tubercle bacilli reach the circulating blood they may be carried to many organs and tissues at once, causing a tuberculous septicemia or miliary tuberculosis. In such cases at autopsy the miliary tubercles are found everywhere in the body.

It is well to distinguish between the words "tubercular" and "tuberculous," as they are often used incorrectly. The word tubercular means nodular and has no reference to the nature or cause of the nodule. Tuberculous, on the other hand, is an adjective used to indicate tissues infected with tubercle bacilli.

Toxins.—The damage done in tuberculosis is due almost entirely to the absorption of the toxins formed by the tubercle bacillus. These are of two kinds: an extra-cellular or soluble toxin, to which is attributed the fever, headache, loss of appetite and so on, and an endotoxin which causes an irritation of the tissues, leading to the formation of the tubercle. The absorption of

these toxins causes the formation of anti-bodies but not in sufficient amount to cause immunity.

Diagnosis.—The toxins of the tubercle bacilli may be obtained either from cultures, or by extracting them from the bodies of the bacilli and are used under the name of tuberculin in the diagnosis and treatment of the disease. The tuberculin reaction used in the diagnosis is based upon an observation made by Professor Koch, that animals having tuberculosis were very sensitive to the poison, and when injected with even a small amount of tuberculin, developed fever, headache, nausea, vomiting, and general malaise, while the diseased tissues became temporarily more inflamed. Healthy animals were unaffected. This method has been employed among tuberculous patients, using from 1 to 10 milligrams of the tuberculin subcutaneously. Simpler methods have more recently been used, such as the von Pirquet test, in which the tuberculin is introduced into the superficial layers of the skin with a scarifier, and the Moro test, in which the tuberculin is rubbed in, in the form of an ointment. In the first method a positive reaction is manifested by fever, headache, and so on, as described above, but in the cutaneous tests there is only a local redness about the point of inoculation. A positive test means that tuberculosis is present in the body, but it does not tell us where, or whether it is active or not. In children, a positive reaction usually means active disease. Complement fixation tests for the diagnosis of tuberculosis may be done but have not proven entirely reliable.

Tuberculin Treatment.—Tuberculin administered in increasing doses, too small to cause a reaction, and at

fixed intervals, develops a tolerance for the poison, and so an immunity. This method of treatment is being widely used and while the results are not prompt, the consensus of opinion is that in some cases it exerts a beneficial effect on the course of the disease.

Crusade Against Tuberculosis.

Public Health Measures Adopted.—During the last ten years great efforts have been made to check the ravages of this disease; in fact, a crusade has been carried on that has become world-wide. Among the measures that have been advocated are the registration of all cases of tuberculosis by departments of health; the establishment of institutions sufficient to care for the advanced cases; dispensaries where suspected cases may be examined and subsequently visited by nurses who instruct the sick in the proper way to disinfect the sputum, stools, and urine; and the disinfection of all houses occupied by tuberculous patients before being reoccupied.

A very important part of the work consists of searching for the disease in people who have been in contact with those sick with it. The physical examination of school children to discover those that are undernourished and those with defects of the respiratory tract, such as infected tonsils and adenoids, is an important part of tuberculosis prevention. More general measures, such as better sanitary conditions in factories, schools, and dwellings, have been brought to the attention of the public, and have created a public sentiment that is now bearing fruit. As a result of this crusade, it is not too much to expect that the death rate from

tuberculosis will be materially reduced, and that the spread of the disease will be checked.

THE BACILLUS OF LEPROSY.

Morphology.—The bacillus causing leprosy was found by Hansen, a Norwegian, in 1871, in the nodules of leprous patients. It is a short rod about the size of the tubercle bacillus, which it resembles closely both in appearance and in staining peculiarities. It takes stains with difficulty, but once stained it resists decolorizing with acids. For this reason it is spoken of as being acid-fast. It is very difficult to cultivate on the culture media at our disposal. Efforts to transmit the disease to animals have not been successful. The organisms can be found in the affected skin. They are scattered through the abdominal organs in fatal cases. They are present in the nasal secretions, and have been found in the circulating blood.

Distribution of the Disease.—Leprosy is one of the oldest diseases known, and Dr. Osler says it existed in Egypt three or four thousand years before Christ. It is referred to many times in the Bible, but there is reason to believe that other diseases were included under the same name. The disease has continued to exist to the present time, but was particularly prevalent in the Middle Ages. At present it exists in Iceland, Norway, Sweden, Russia, Spain, Portugal, England, West Indies, China, India, and the Philippines. In the United States small numbers of cases are to be found in Louisiana, Minnesota, Florida, and Texas, with isolated cases widely scattered.

The disease manifests itself either as tubercular leprosy or as anesthetic leprosy. In the former, large nodules develop in the skin, and on the face cause great disfigurement. In the anesthetic form the nerves are principally affected, and this leads to the formation of flat pigmented spots that are devoid of sensation. The spots atrophy and ulcerate. Both forms may exist at the same time.

Infection.—The way that infection takes place is not positively known, but many believe that it enters the skin or mucous membrane through close personal contact. While hereditary transmission cannot be denied, no instance has so far been recorded. The infectious material is found in the discharges from the open sores, in the urine, milk, blood, sputum, and nasal secretions. The last are especially infectious.

The spread of the disease is checked by the segregation of the lepers in the communities where the disease prevails. Attendants upon leprous patients should know that the disease is one of the most difficult to contract of all the infectious diseases, and that it is very rare for nurses to be infected while attending cases. Careful attention should be given to disinfecting the nasal discharges and sputum.

Questions in Review.

1. What are the characteristics of the tubercle bacillus?
2. Name the various kinds of tubercle bacilli.
3. Describe the method of staining the tubercle bacillus.
4. In collecting urine to be examined for tubercle bacilli what precautions should be taken?

5. How may tubercle bacilli be detected in urine and inflammatory exudates?

6. In what ways may tubercle bacilli enter the body?

7. Describe a tubercle.

8. What is tuberculin? What is its value in diagnosis?

9. What part does the Public Health Nurse play in the control and prevention of tuberculosis?

10. How does the bacillus of leprosy resemble the tubercle bacillus?

11. Where does leprosy exist at the present time?

12. Where is the bacillus of leprosy found in those who are infected?

13. What measures should be taken to prevent the infection from spreading?

CHAPTER XV.

DISEASES CAUSED BY SPIRAL ORGANISMS.

Spiral organisms may be grouped in three classes for our purpose, viz.: The Treponema, the Spironema and the Leptospira. They are hard to classify, presenting, as they do, many of the characteristics of both bacteria and protozoa. They are classed here as bacteria largely for convenience. In the Treponema group are the organisms causing syphilis and yaws. The organism causing Vincent's angina is classed as a Spironema. In the Leptospira group are the organisms of hemorrhagic or epidemic jaundice, and yellow fever.

THE TREPONEMA PALLIDUM.

Morphology.—The *Treponema pallidum* is the cause of syphilis. It is a very delicate cork-screw shaped organism with from three to twelve turns and actively motile. It moves by twirling around its long axis. It is pointed at both ends and on one end has a single flagellum. It is very difficult to see under the microscope because it is so delicate, but can be demonstrated by special methods to be described later.

It was discovered by two German investigators, Drs. Schaudinn and Hoffmann, in 1905, and in 1912, Dr. Noguchi, at the Rockefeller Institute in New York, devised a medium on which it could be cultivated.

The treponema causes spontaneous infection only in man. This is followed by the classical symptoms of

syphilis. Infection may be experimentally produced in monkeys. The organism stains with difficulty, so that special stains have been devised for the purpose. They may be seen in unstained preparations either by mixing the infectious material with India ink, which makes them visible on a black background or by darkfield illumination. In this way a device is substituted for

Fig. 30.—*Treponema pallidum,* appearing as bright refractive bodies in a dark field as shown by India ink or darkfield illumination. (Park and Williams. Lea & Febiger.)

the Abbé condenser in which intense light is thrown in from the sides. This makes the field dark (black) but the objects very bright. The treponema can be seen as bright wavy bodies actively moving about. This is the best and easiest method of demonstrating the treponema.

Immunity does not occur after syphilis. It is not possible, however, to re-infect a person that has active

syphilis. No active immunity can be produced by the injection of killed cultures of the treponema and attempts to produce immune serum in animals, that could be used as an antitoxin in human beings have been futile.

Diagnostic Tests.—The diagnosis of syphilis can be made in the laboratory in several ways. The darkfield demonstration of the treponema is of great value, chiefly because the infection can be detected earlier than in any other way. This is of vital importance to the patient, because, the earlier treatment is begun, the better are the chances of cure.

Wassermann Test.—The Wassermann or complement fixation test (see page 82) is universally used and is reliable, with certain exceptions. It will not give positive tests until seven days after infection occurs, and sometimes it requires a much longer time. In the late stages of the disease it will give positive tests in 84 per cent. of the cases. Consequently, negative tests in old cases of syphilis are not always reliable.

Kahn Test.—Precipitation tests, like the Kahn test which is the one most used in the United States, give results which are practically as reliable as the Wassermann test and should be interpreted in the same way.

Luetin Test.—Killed cultures of the treponema may also be utilized for diagnosis by injecting a very small amount of the culture into the superficial layers of the skin. This is called the luetin test, and was devised by Dr. Noguchi. A successful or positive test is shown by the development of a hard, inflamed nodule at the point of injection, and is due to the hypersensitiveness of the skin to the syphilitic poison. The test is of greatest

value in the later stages of the disease when the complement fixation test may not be successful.

SYPHILIS.

From the public health standpoint, syphilis has caused more sickness and the loss of more lives than any other disease. From the medical point of view it is the most interesting of all diseases because of the great variety of pathological conditions it may cause. There is no organ or tissue in the body that may not be attacked. There is practically no disease that it cannot imitate. The aphorism, attributed to Dr. Osler, that "To know syphilis in all of its manifestations is to know medicine," is true.

Distribution. — The disease was introduced into Europe, it is believed, by Spanish sailors in the time of Columbus. It was contracted by them at Haiti and carried back to Spain by them. Thence the infection spread through Europe. Since then the disease has been widespread.

In the United States Army during the last war there were 67,026 cases of syphilis, among the 4,122,930 men in the service. When one stops to consider that everyone with syphilis must contract the infection from someone else that has it, it is easier to understand how widespread syphilis is.

Path of Infection.—The infection takes place through small injuries or cracks in the skin or mucous membranes, although Noguchi believed the treponema could bore through uninjured skin. It is spread, in the vast majority of cases, through sexual intercourse. On this account, syphilis has been termed a venereal disease.

It is quite possible, however, to become infected in other ways. People with syphilitic sores in the mouth may transmit the infection to others by kissing, or from drinking glasses or eating utensils that they have used. Wet-nurses may become infected by nursing a child that is infected. Physicians may become infected in the performance of professional duties, as in the examining of patients and in the attendance of women in confinement. Children may be infected in the uterus or, during labor, from sores in the vagina of the mother.

Manifestations of the Disease.—Infection manifests itself first by a sore called a chancre which develops from three to six weeks after exposure. This sore is hard and indurated, usually single, and heals slowly. It may be located anywhere on the body, but is always at the point where infection entered. The organisms are at first localized in the primary sore, but very soon spread to the glands near by, and then to the blood, causing a general infection. The result is a general skin eruption, sore throat, fever, and anemia—symptoms that develop in from six to twelve weeks after the chancre, and mark the beginning of the secondary stage. Later the spirochetes become localized in certain tissues, particularly the brain and spinal cord, and often lead to the formation of nodules which have a tendency to become soft and cheesy. A nodule of this sort is called a gumma and is characteristic of the tertiary stage of syphilis.

The late manifestations of syphilis are serious. The disease may remain dormant for years, only to reappear in some vital organ or tissue. Tertiary syphilis of the blood-vessels causes arteriosclerosis and aneurism of

the aorta. In the liver it causes cirrhosis with the formation of nodules often mistaken for cancer. The disease is very destructive to bony tissue. It may cause blindness and deafness. In the brain its destructive effects cause general paresis, and in the spinal cord, locomotor ataxia.

Syphilis and Public Health.

The menace of syphilis to the public health has been recognized by physicians for many years. Among lay people little was known of it. It was talked about very little among men, and among women the subject was taboo.

A Campaign of Education.—The alarming extent of the disease during the war led the United States Public Health Service to start a campaign of education in this country based on the belief that the chief factor in the spreading of this and the other venereal diseases was ignorance. The moral issue involved has had no part in this campaign. As a result, in New York and many other states the health department has made these diseases reportable, has established free clinics for treatment, a large educational program has been carried on, legislation has been enacted, making treatment for the infected compulsory, and better facilities for hospital care have been provided.

The Nurse's Part.—The nurse has a definite part to play in this campaign. She will be asked about syphilis and the venereal diseases by the patients she will attend. It is important, therefore, that she should be able to give accurate information and so do her part in this program of education. In attending patients infected

with syphilis, the nurse should know that the disease is highly infectious only in the first and second stages. The third stage offers very little danger of infection. First and second stage cases rarely need hospital care except in the case of babies with active hereditary syphilis. In such cases the nurse should use rubber gloves in caring for them. The treponema of syphilis is easily and quickly killed by a 1:1000 solution of bichloride of mercury. Immersing the hands in this solution will afford ample protection against infection.

SPIROCHÆTA PERTENUIS.

This spirochete is the cause of frambesia tropica, or yaws, a disease that is much like syphilis. It prevails in tropical countries and affects children more than adults. This spirochete is similar in appearance to the treponema of syphilis.

The disease starts with a single sore or papule. In the secondary stage there is a generalized eruption of raspberry-like growths accompanied by fever, headache, and malaise. It is readily transmitted by contact infection from one child to another. It responds to treatment with arsenical preparations like arsphenamine, even more promptly than syphilis.

THE SPIROCHETE OF RELAPSING FEVER.

The cause of relapsing fever is a group of spirochetes, the individual members of which differ in minor details in the various countries where the disease prevails. The spirochetes are long, delicate threads with four to ten spirals and an undulating membrane which

propels them about actively. They can be found in the blood of those sick with the fever by darkfield examination or in stained smears. At present the infection is most widespread in India and Africa, but sixty to seventy years ago epidemics occurred in this country.

Symptoms and Transmission.—People infected with the spirochetes develop a fever of relapsing type. First

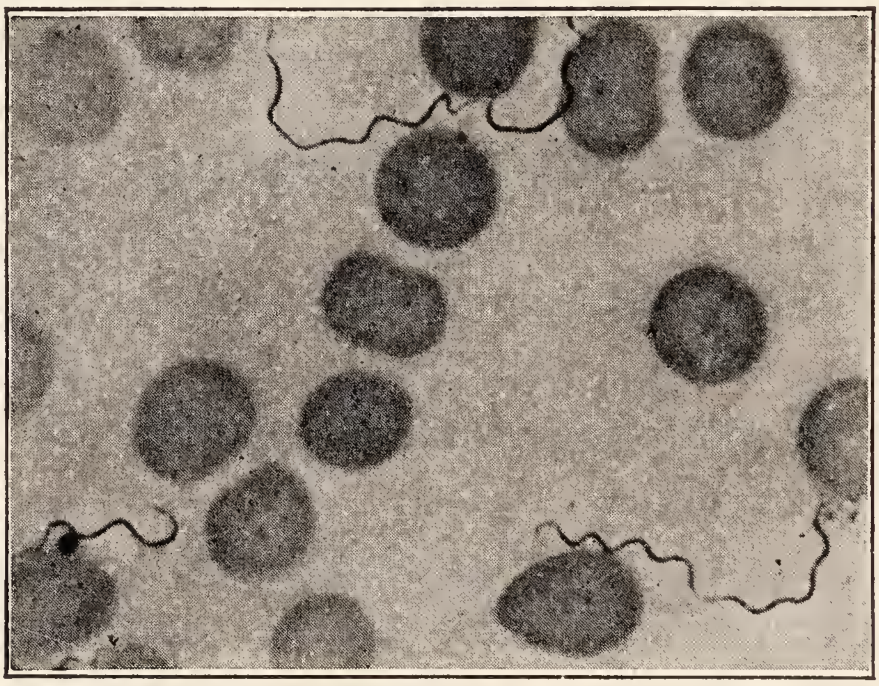


Fig. 31.—Spirochete of relapsing fever. (Zinsser, after *Calkins*. D. Appleton & Co.)

there is a period of high fever lasting from five to seven days, then a period of remission of seven to fourteen days. As many as five such attacks may occur. It is rarely fatal. It is spread by the bites of lice and ticks which become infected by sucking the blood of patients having the disease. One attack usually confers immunity. In preventing the spread of the disease it is important to isolate the patient and disinfect the bedding, clothing, and apartments. Particular attention should be given to the extermination of lice and ticks.

VINCENT'S ANGINA.

This is an infectious disease of the gums, mouth, or throat, characterized by the formation of a membrane which may be almost identical with the diphtheritic membrane in appearance, or by ulcerations which have a punched-out appearance. On the gums it may produce extensive ulcerations. In smears made from the

Fig. 32.—Organisms of Vincent's angina in throat smear, showing fusiform bacilli and spirilla. (Zinsser. D. Appleton & Co.)

membranes or ulcers, large, fusiform bacilli, broad in the middle, with tapering ends and long spirilla, are constantly found and are supposed to be the cause of the infection. It was the belief that the spirilla were but a later stage in the development of the fusiform bacilli, but there is reason to believe this is not so. As both forms are difficult to cultivate, the diagnosis must be made by examining smears made directly from the membrane or ulcerations in the throat. These organ-

isms may be present with the bacilli of true diphtheria, and are said to aggravate the infection.

The disease is usually mild and responds fairly promptly to local treatment, but in some cases where the nature of the infection has not been recognized and properly treated, the ulceration and destruction of tissue in the throat may be extensive. It is spread directly from person to person through the secretions from the mouth. The danger of becoming infected is not great.

YELLOW FEVER.

This is an acute infectious disease caused by a spiral organism called the *Leptospira icteroides.* It was discovered in 1918 by Dr. Hideyo Noguchi of the Rockefeller Institute. He was able to cultivate the spirochete from patients sick with the disease and from guinea pigs that had been infected with the blood of yellow fever patients.

The organism is a very delicate spiral with thick pointed ends. It is not visible by daylight but can be seen by darkfield examination. It is actively motile and is difficult to stain.

Transmission.—The infection is transmitted by a certain kind of mosquito called the Stegomyia fasciata or calopus. The insects become infected by sucking blood from yellow fever patients in the first few days of the illness. The insects thus infected are not able to transmit the disease to human beings until at least twelve days have passed.

Symptoms.—The disease has a sudden onset with fever, flushed face, and jaundice. Albumin in the urine appears early in the disease. The fever leaves after

two or three days in favorable cases (the period of calm) only to return for two or three days more. The pulse is slow even when the temperature is high. Hemorrhages into the skin, mucous membranes, and stomach, the last causing black vomit, are common. Recovery is followed by permanent immunity.

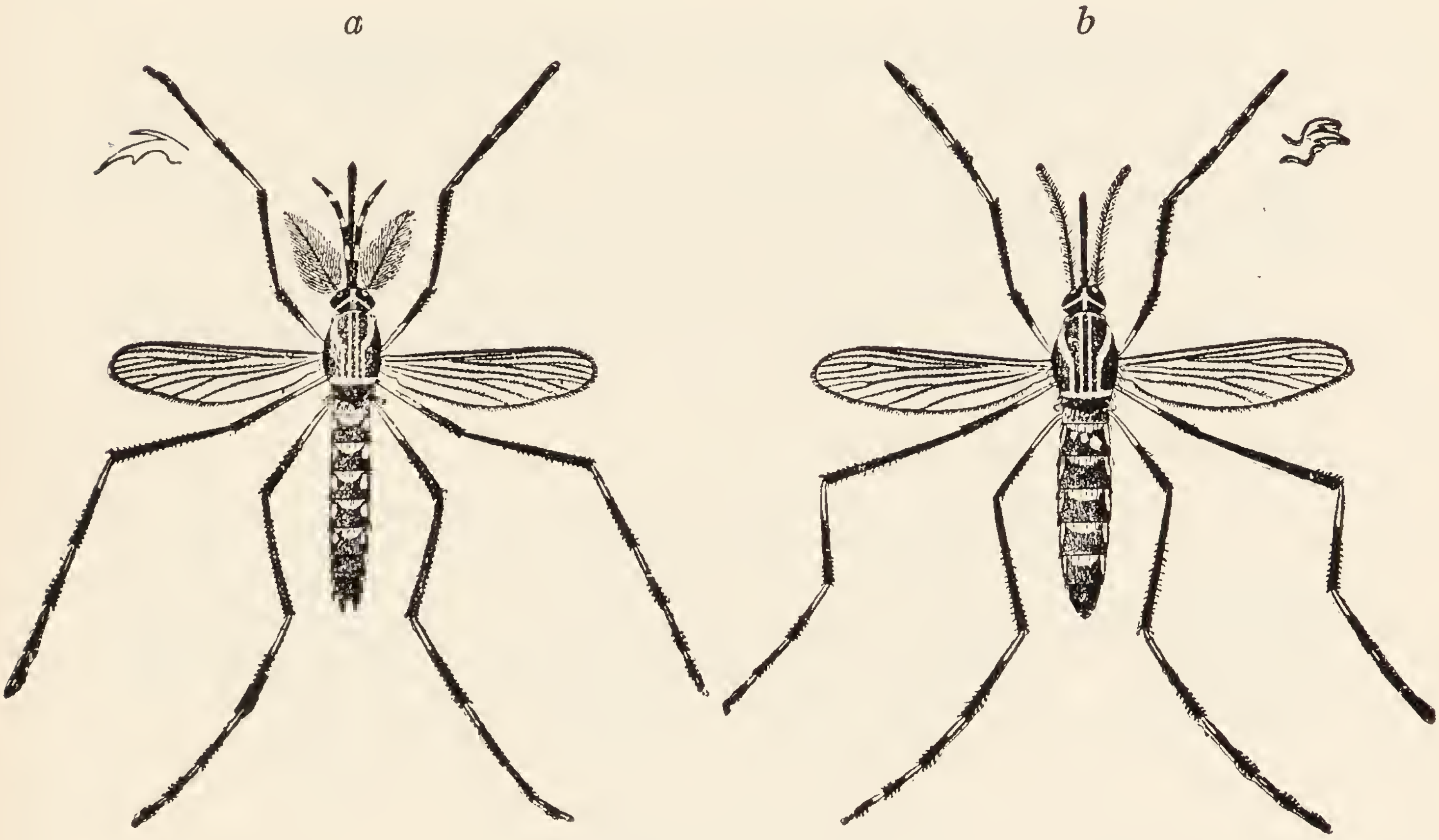


Fig. 33.—The stegomyia or yellow fever mosquito. *a*, female; *b*, male. (Zinsser, after *Carroll*. D. Appleton & Co.)

Distribution.—Yellow fever is a disease of tropical countries. It was endemic in Cuba, Panama, and many South American countries until recently. There have been numerous localized epidemics in the United States.

Prevention.—The discovery by the Commission of United States Army Surgeons in 1900 that the disease was transmitted by the mosquito immediately pointed the way to prevention. It is never carried by personal contact. Prevention, then, consists in keeping mos-

quitoes from breeding by the draining of stagnant bodies of water and destroying them in houses by insecticides. Houses must be screened, and particularly patients, so that mosquitoes may not become infected from them.

As a result of these preventive measures, yellow fever has become a rare disease.

EPIDEMIC JAUNDICE (WEIL'S DISEASE).

This disease is caused by a spiral organism called the *Spirochaeta icterohemorrhagiæ.* It is quite like the spirochete of yellow fever in appearance.

The disease is marked by a fever of sudden onset. This is followed in a few days by jaundice, hemorrhages into the skin, and anemia.

It is transmitted to man from the urine of infected rats. It seems to prevail during war times when large numbers of troops are living in crowded quarters. Here, too, the urine probably carries the infection.

Questions in Review.

1. What is the appearance of the *Treponema pallidum?* How may it be demonstrated under the microscope?

2. In what ways may syphilis be diagnosed?

3. In what ways may syphilis be contracted? What is the primary sore?

4. What is the significance of a negative Wassermann reaction?

5. Why is syphilis called the "great imitator"?

6. What are the stages of syphilis? What stage of syphilis is most infectious?

7. Why are the late manifestations of syphilis most serious?

8. What part can the nurse take in the educational campaign against syphilis?

9. What are some of the points of difference between syphilis and yaws?

10. Where is relapsing fever prevalent at the present time?

11. How may the organism causing this disease be detected? How is it spread?

12. What is meant by a "relapsing fever?"

13. What is the appearance of the organisms causing Vincent's angina? How may they be detected?

14. How is the infection of yellow fever transmitted?

15. What are the symptoms of the disease?

16. What may be done to prevent yellow fever?

17. What characteristic symptoms develop as a result of infection with the *Spirochæta icterohemorrhagiæ?*

18. How is this infection transmitted?

CHAPTER XVI.

THE DISEASES CAUSED BY THE MOLDS, YEASTS AND HIGHER BACTERIA.

Referring back to the classification of the fungi given in Chapter II, page 19, there still remain to be considered the hypomycetes, or molds, and the blastomycetes, or yeasts. Under the head of higher bacteria are organisms having characters that make it difficult to classify them either as molds or yeasts. The most important of the higher bacteria is:

ACTINOMYCES.

This infection generally runs a chronic course, and is caused by the actinomyces, or ray fungus. It prevails chiefly among cattle; but sheep, dogs, cats, horses, and swine are also susceptible. It occasionally occurs in man (Fig. 34).

Morphology.—The parasites can be seen by the naked eye, in pus from the abscesses, as minute, yellow masses, often called sulphur granules. If the granules are examined under the microscope they are found to be made up of a central thick mass of filaments which radiate at the periphery. It is because of this radial arrangement that the parasite is called the ray fungus. The ends of the filaments are often club-shaped.

Infection.—The infection is located most often about the mouth or in the throat. It starts as a nodule, hard at first, but later undergoes softening and finally suppur-

Fig. 34.—Actinomyces in smear showing branching organisms. ×1500. (Park and Williams, after *Wright*. Lea & Febiger.)

Fig. 35.—Actinomyces hominis (lung). × 350. (*Lenhartz-Brooks.*)

ates, causing a discharging sinus. Infections of the skin, lungs, intestines, and appendix have been described. In the lungs and intestines it is usually fatal. The parasite is supposed to enter the body of man in grain, oats, barley, or rye, and in cattle from hay or straw.

The disease is not highly infectious and all danger is removed by careful disinfection of the discharges containing the pus.

Fig. 36.—Yeast cells, unstained. (Zinsser, after *Zettnow*. D. Appleton & Co.)

YEASTS.

Morphology.—Yeast cells are much larger than bacteria; they are oval in shape and have a thick cell-membrane. The protoplasm contains vacuoles and one or more nuclei. The manner of reproduction is characteristic; the capsule protrudes and forms a bud and contains a part of the protoplasm and a half of the

nucleus. It gradually grows larger, and is eventually pinched off to become another cell. The cells frequently contain spores, which are liberated when the cell disintegrates.

The most important property of yeasts is the fermentation of sugars, whereby the sugar is changed into ethyl alcohol and carbon dioxide. Commercially the yeasts are used in a variety of ways, but chiefly in the

Fig. 37.—Blastomycosis in infant. (Park and Williams (after *Kessler*). Lea & Febiger.)

manufacture of beers and wines. Few of the yeasts are infectious for man, and but one will be mentioned.

Blastomyces Hominis.

The infectious disease caused by this group of yeast organisms is called blastomycosis. In appearance the blastomyces correspond to the yeast cells described above, having a thick cell wall with one or more nuclei in the protoplasm, and vacuoles. Occasionally they form

threads called mycelia (singular, mycelium). They may be cultivated with difficulty on glucose agar.

The skin is most often affected. Small nodules form, which soften and discharge a yellow pus. They spread slowly and sometimes involve a considerable area of skin. Infection of the lungs is more serious and often leads to pneumonia. A few cases of general infection have been reported with abscesses in the liver, spleen, and lungs. The infection is detected by finding the organism in the pus.

Where the organisms that cause the disease come from is not known, but in skin infections it is presumed that they enter along the hairs or through small abrasions. It is not a very infectious disease, and the infection of others may be prevented by disinfecting the pus discharged.

MOLDS.

The molds in their structure are much more complex than the yeasts. They are characterized by the formation of mycelial threads and terminal organs of reproduction called hyphæ. They may be seen growing on decomposing substances, and look like little pieces of cotton. Of the many kinds of molds, but a few are pathogenic for man.

Pityriasis Versicolor.

The infectious mold here is the *Microsporon furfur*, which lives on rather than in the skin. It produces yellowish, scaly, patches on the chest, back, or abdomen, which may spread over large areas of the skin. When scratched, the growth can be removed in fine scales

which contain the mold. It affects chiefly the uncleanly. It is easily destroyed by antiseptics.

Thrush.

This occurs in infants and young children, causing sore mouth. It is caused by a mold called the *Oidium albicans.* The mucous membrane is red and dotted with small, white flakes, which contain the organism. It is easily destroyed by antiseptics.

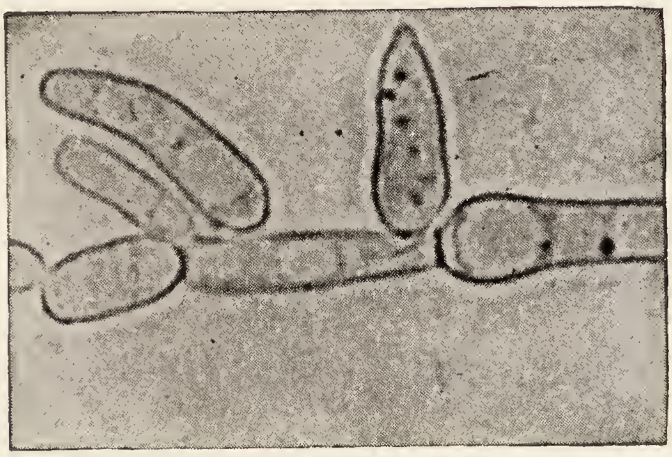


Fig. 38.—Thrush—oïdium albicans unstained. (Zinsser, after *Zettnow.* D. Appleton & Co.)

Favus.

The mold causing favus is called the *Achorion Schonleini,* after its discoverer. It attacks the hair-follicles, especially of the scalp, and forms yellow crusts about the base of the hairs. If the crusts are removed and examined under the microscope, the parasites can be found in them. The disease is very resistant to treatment. It occurs more frequently in Europe than in the United States.

Ringworm.

This is a very common affection among children, and is caused by the *Tinea trichophyton.* There are three

types of the parasite: the *Tinea tonsurans,* which attacks the hairs of the scalp; the *Tinea sycosis,* which attacks the hairs of the bearded part of the face, and the *Tinea circinata,* which attacks the skin. It starts as a slightly elevated, scaly spot, which gradually widens,

Fig. 39.—Epidermophyton Inguinale. × 200. The fungus of "gymnasium feet." (Zinsser. D. Appleton & Co.)

forming a red, scaly patch, with raised edges. The hairs invaded by the parasites break off and leave the center devoid of hair. The disease spreads from one person to another by direct contact.

Tinea Epidermophyton.—In the last few years ringworm of the hands and feet has been increasingly common. The infection is due to the *Tinca epidermophy-*

ton. It produces small vesicles between the fingers and toes, chiefly. Infection of the feet seems to occur in the shower-baths of gymnasiums and country clubs.

Questions in Review.

1. What is characteristic in the appearance of the actinomyces?

2. Where is the infection most often found?

3. How are human beings infected?

4. How may the disease be detected?

5. What is the appearance of the blastomyces under the microscope?

6. How does the infection manifest itself in man?

7. How do molds differ from yeast?

8. Name the pathogenic molds.

9. What tissue of the body do molds affect chiefly?

CHAPTER XVII.

THE BACTERIA IN WATER AND MILK.

THE BACTERIA IN MILK.

From its appearance and taste little can be known of the bacterial content of milk. It may be teeming with bacteria, yet give no indication of their presence. In fact, ordinary raw market milk contains from 100,000 to 1,000,000 bacteria in every cubic centimeter (15 drops).

Source of Contamination.—How do these bacteria get into the milk? In the udder of the healthy cow the milk is practically free from bacteria, but they live in the milk ducts in the teats, and get into the milk as it is drawn. The chief source of bacteria in milk lies in the uncleanly methods of collecting it. Many get in from the dust-laden air of the stable, from the dirt on the hide of the cow, unclean milk pails and from dirty hands of the milkers. It is a true saying that the number of bacteria in milk is an index of the cleanliness with which it has been collected. Once in the milk, the bacteria multiply with great rapidity; for milk is an excellent medium for the cultivation of bacteria. The temperature of the milk for some time after it is drawn also favors their development.

Prevention.—To prevent the contamination of milk with excessive numbers of bacteria, all that is required is cleanliness—clean stables, clean cattle, milkers with clean hands, and clean milk pails. Immediately after

the milk is drawn, it should be cooled to 50° C. (122° F.) and kept at this temperature until sold.

Health Department Requirements.—The State Department of Health of New York, recognizing the importance of clean milk and the various purposes for which it is used, has established several grades of milk and cream with the requirements for their production.

Grade A—Raw Milk.—The cows must be tested with tuberculin at least once a year. Milk must not contain more than 60,000 bacteria per cubic centimeter, and cream not more than 300,000 bacteria.

Grade A—Pasteurized.—The number of bacteria per cubic centimeter must not be more than 30,000 in milk and 150,000 in cream.

Grade B—Raw.—The number of bacteria must not exceed 200,000 per cubic centimeter in milk and 750,000 in cream.

Grade B—Pasteurized.—The number of bacteria per cubic centimeter must not exceed 100,000 in milk and 500,000 in cream.

Grade C—raw milk has no limit placed on the number of bacteria. These grades are intended for special purposes. For infant feeding, Grade A, raw or pasteurized, should be used; for ordinary table use, Grade B, raw or pasteurized; and for cooking Grade C.

Medical Milk—Commission Control.—Certified milk is the highest grade of raw milk, intended chiefly for use in infant feeding. In the United States certified milk is produced under the control of a medical milk commission of the County Medical Society. The rules adopted by the American Association of Medical Milk Commissions must be followed. These relate to all the

phases of milk production and have as their object the production of the highest possible grade of raw milk and the prevention of any infection of the milk either from the herd or the employees. Certified milk must not contain over 10,000 bacteria per cubic centimeter and the fat must average 4 per cent. It costs considerably more to produce certified milk and therefore it is more expensive to buy.

Pasteurization.—Pasteurization is accomplished by heating the milk to 60° C. (140° F.) for thirty minutes or 65° C. (149° F.) for fifteen minutes. The milk is immediately cooled to 50° C. (122° F.) and kept at this temperature until used. Milk to be used in feeding infants should be modified and poured into the nursing bottles before being pasteurized. The use of pasteurized milk is constantly increasing. In some cities no raw milk can be sold. The reason for this is simple enough. Pasteurization destroys the bacteria of those infections that may be spread in milk. There has been a long controversy as to whether pasteurization destroys some of the nutritive value of milk or not. It destroys some of the vitamins but is much safer for general use than raw milk. It should be used within twenty-four hours.

Dangers of Bacteria in Milk.—The bacteria usually present in milk are harmless in so far that they are unable to produce specific disease; but while they may be considered harmless for healthy adults, they may be very dangerous for infants and sick persons. The great loss of life among infants under two years of age from intestinal or diarrheal diseases shows this. During the summer months, when the number of bacteria is more

than at any other time of the year, the milk undergoes chemical changes which lead to disturbances in digestion and infection of the intestines.

The number of bacteria in milk is determined either by counting the number of colonies developing on agar plates that have been inoculated with a given quantity of milk or by counting directly under the microscope the number present. The result is expressed by the number of bacteria per cubic centimeter.

Diseases Transmitted by Milk.—Diseases other than those caused by the ordinary dirt bacteria may be spread in milk. Many epidemics of scarlet fever, typhoid fever, diphtheria, and septic sore throat have been traced to infected milk. Infection with undulant fever is rapidly increasing from the use of milk from infected cows. Infectious agents are introduced into the milk at the dairy, usually by someone sick with the disease in question.

Tuberculosis.—The transmission of tuberculosis in the milk from tuberculous cattle is believed to be of common occurrence, particularly among infants. The tubercle bacilli may pass through the walls of the intestine without causing any disease of the intestinal wall itself, and lodge in the mesenteric lymphatic glands. They may lie dormant for years and later on, when the resistance is lowered by disease or by unsanitary conditions of living, become active and cause tuberculosis in whatever organ or tissue they may be lodged. The milk from cattle having tuberculosis of the udder is the most dangerous but even when the udder is healthy and the disease located in other organs, the milk may contain tubercle bacilli. Not only is the milk from tuber-

culous cattle infectious, but also the products—butter and cheese—made from the milk. From what has been said, it is easy to see the danger of using raw cow's milk. When one stops to consider that the milk supply of a large city comes from an area of thousands of square miles daily and from thousands of farms in this area, it is not hard to understand that milk inspection is, to say the least, difficult. In view of the dangers involved, particularly to young children and infants, pasteurization is the only safe milk, in the writer's opinion.

THE BACTERIA IN WATER.

Water as it falls in the form of rain is free from bacteria. It begins to be contaminated with bacteria when it reaches the dust-laden air above the earth, and after it reaches the ground the number of bacteria is greatly increased from the soil. As it drains from the surface of the earth or percolates through it, it is classed either as surface water, of which ponds, lakes, or rivers are examples, or as ground water beneath the surface, which feeds wells. Surface water always contains large numbers of bacteria, but the water in wells contains only a few, on account of the filtering action of the soil. While the number of bacteria in surface water is large, there is going on constantly processes of purification which keep the number in check.

Natural Methods of Purification.—First, there is sedimentation or the sinking of impurities by reason of their weight. The effect of sedimentation can be seen after floods, where the mud and dirt is found over the flooded areas. Sedimentation takes place slowly; so in streams that are flowing fast it cannot be relied upon

to remove much of the impurities. Aëration is another factor. This means the mixing of water with air, as takes place, for example, in water-falls. It does not destroy the bacteria but it removes objectionable odors. Sunlight exerts a powerful destructive action on the bacteria in water, provided the depth of the water is not too great for the sunlight to penetrate. Unfortunately, the penetrating power of sunlight is not great; so its action is limited to the upper layers of the water. The ground water is purified by the filtering action of the soil, which is very efficient, provided the amount of water to be filtered is not too great and the soil is not required to work continuously.

Harmless and Harmful Bacteria.—The ordinary soil bacteria in water are harmless. It is only the pathogenic bacteria in the soil from human excreta, like the typhoid and dysentery bacilli and the cholera spirilla that may get into the water, that cause disease. In testing the water to see whether it can transmit these diseases or not, it is almost useless to look for the disease-producing bacteria themselves, because they are extremely difficult to find. The presence of intestinal bacteria is looked for, particularly the colon bacillus, and when they are found in large numbers the water is condemned for drinking purposes: first, because drinking water should not contain substances excreted from the intestines of man or animals, and, second, water that does contain such substances is constantly open to infection with bacteria that produce disease.

Tests for Detecting Sewage Contamination.—The number of bacteria in water may be determined by mixing varying amounts of water, usually 1 cubic centi-

meter, in melted agar and spreading on agar plates. After incubation for twenty-four hours the number of colonies can be counted. The colon bacillus in water may be detected by inoculating fermentation tubes containing fluid sugar medium. The colon bacillus will cause fermentation of the sugar and gas will collect in the upper part of the tube. This is a presumptive test. Cultures are now made in various sugar media. The resulting fermentations will enable one to detect the colon bacillus.

Artificial Methods of Purification.—Nowadays practically all surface waters are contaminated with human sewage. To render these waters safe for drinking purposes in cities, the natural process of water purification cannot be relied upon, and artificial methods, based on filtration, are employed. The water may be made to percolate through beds made of fine gravel and covered with a thick layer of fine sand. The dirt and slime in the water cling to the small particles of the sand, and only the water free from its impurities is permitted to pass through. About 95 per cent. of the bacteria in water can be removed by sand filtration. In mechanical filtration, a chemical substance like alum is added to the water in sufficient quantity to coagulate the solid and extraneous materials, which sink and carry the bacteria with them. In the home, water may be rendered pure by filtration through porcelain filters, and, where these are not available, by boiling. The flat taste of boiled water may be removed by passing the water from one container to another so that air may be mixed with it.

Chlorination of water is being practiced a great deal in recent years. Chlorine gas, liberated from chemicals put into the water, destroys the typhoid group of organisms in a few hours. The taste of the chlorine may be detected at times but it is not injurious, although it may give the water a disagreeable taste. Chlorination is also used a great deal to purify the water in swimming pools.

Questions in Review.

1. How do bacteria get into milk?

2. How may the number of bacteria in milk be kept low? How may the number of bacteria in milk be determined?

3. Why does cream contain more bacteria than milk?

4. What is the object of "grading" milk?

5. How is pasteurization performed?

6. Discuss the advantages and disadvantages of pasteurized milk.*

7. What diseases may be milk borne?

8. How does water become contaminated by bacteria?

9. Why does well water contain fewer bacteria than surface water?

10. How may the number of bacteria in water be determined?

11. What is the significance of colon bacilli in water?

12. What are the natural methods of water purification?

13. Describe the artificial methods of water purification.

14. Why is it unsafe for cities to use natural water supplies?

15. What diseases may be water borne?

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* May be used as a subject for debate.

CHAPTER XVIII.

DISEASES CAUSED BY PROTOZOA.

In the classification of micro-organisms in Chapter II, they were divided into two great classes: Those belonging to the animal and those belonging to the vegetable kingdom. So far we have studied only the vegetable micro-organisms—the molds, yeasts, and bacteria. The protozoa (singular, protozoon) represent the lowest form of animal life, and are composed of a single cell made up of a nucleus surrounded by a mass of protoplasm. The protoplasm is concerned with the nutrition of the cell, while the nucleus controls the vital functions, particularly reproduction. Comparatively few of the many species of protozoa are known to be pathogenic for man. The life cycle of the protozoa is peculiar, and differs from that of bacteria, in that part may be lived in the body of some animal, and part outside the body. During the cycle they may take on various shapes and sizes.

PARASITIC AMEBÆ.

Two species of amebæ are found in man, one is pathogenic, the *Entamœba hystolitica,* the other is harmless, the *Entamœba coli.* They exist in both a vegetative and encysted form. The vegetative form is not so infectious as the encysted form, the latter being much more resistant.

Structure.—In structure the ameba, in the vegetative form, is composed of an outer clear zone and an

inner granular zone of protoplasm which contains the nucleus. The protoplasm frequently contains cavities called vacuoles. It moves by extending a portion of the outer clear zone, called a pseudopod, into which the rest of the cell body flows. These pseudopods may also embrace small particles of food, blood cells, and bacteria, and take them into the body of the cell.

Fig. 40.—Ameba coli, showing pseudopods. From dysenteric stool. (Zeiss Apochr., 1; oil immersion, 1/12) (After *Lösch.*)

In the encysted stage the outer layer of protoplasm becomes dense and forms a cyst wall. There is no motility in this stage. Reproduction takes place either by simple division or by budding, in which a portion of the nucleus and the protoplasm protrude from the margin and are eventually pinched off to make a new cell.

Amebic Dysentery.

The infection with amebæ comes chiefly from chronic carriers who have recovered from the disease, although people who have never had amebic dysentery may carry and spread the infection. Carriers having to do with the preparation of food are especially dangerous. It is in the encysted form that the ameba is most infectious.

The ingested amebæ lodge in the intestine and cause changes leading to ulceration. The dysentery resulting is of long duration. Relapses are common. The stools may be as many as twenty a day and contain blood and mucus. Anemia results from the loss of blood, and the loss of weight may be extreme. The amebæ frequently find their way into the liver to cause abscess formation. The disease occurs in tropical countries, in Egypt, India, and in the southern part of the United States. Occasionally it is found in the northern states. Two cases, one with abscess of the liver, have come under the observation of the writer in Troy, N. Y. Amebic dysentery never occurs in epidemic form. As mentioned above, the disease is of long duration but much success follows the ingestion of ipecac or its active principle, emetin.

The stools contain the amebæ and to prevent the disease from spreading, they should be disinfected with a 5 per cent. solution of carbolic acid. Carriers should be isolated.

Diagnosis.—The diagnosis of amebic dysentery is made by finding amebæ in the stools. This is done by examining the mucus or pus in the stool under the mic-

roscope. If the vegetative form is looked for the material must be kept warm in order to preserve the motility. The encysted form is seen best in stained preparations.

MALARIAL PARASITES.

Malarial Fever.

Malarial fever is an acute infection caused by a protozoan parasite called a plasmodium. They are of three species identified by their structure and appearance. There are three types of the fever caused by the three species of the parasite: The tertian type, with chill and fever every third day; the quartan, with chill and fever every fourth day; and the estivoautumnal, with an irregular fever like typhoid. The infection is characterized by chills, intermittent fever, anemia, and enlargement of the spleen.

Distribution.—Malaria at the present time is prevalent in India, in Africa, and Central America. In the United States it has diminished from year to year but still prevails in some of the southern states. In the north it occurs rarely nowadays.

Transmission.—The disease is transmitted from one person to another by the female mosquito of the genus Anopheles. They can be distinguished from the ordinary mosquito, the Culex, by their position when they alight. The body of the Culex is always parallel to the surface, while the body of the Anopheles forms a sharp angle with it. When the Anopheles feeds on infected blood the malarial parasites are taken into the stomach and undergo reproduction. After seven to ten days they find their way to the salivary glands. When the

mosquito bites man the parasites are excreted with the saliva into the wound. In the blood the parasites enter and develop within the red blood-cells. As they grow they fill more and more of the corpuscles and finally be-

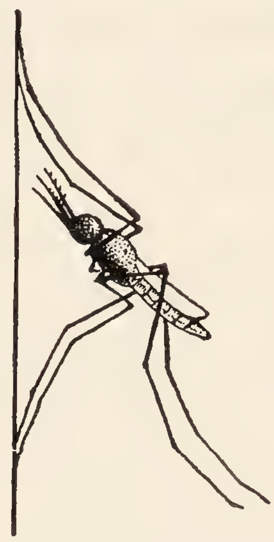

Fig. 41.—Mosquito Anopheles. (Park and Williams. Lea & Febiger.)

Fig. 41*a*.—Mosquito Culex. The body of the Culex is parallel to the surface on which it rests, while the body of the Anopheles is at a decided angle.

come segmented into smaller bodies that are to become parasites. When this development is complete, requiring forty-eight or seventy-two hours, depending upon the type of parasite, the red blood-corpuscle is ruptured and the segments and a toxin are set free in the

circulating blood, causing the chill and fever that are so characteristic of the disease. In this way more and more blood-cells are attacked and destroyed, which explains the anemia.

Diagnosis.—The diagnosis is made by finding the

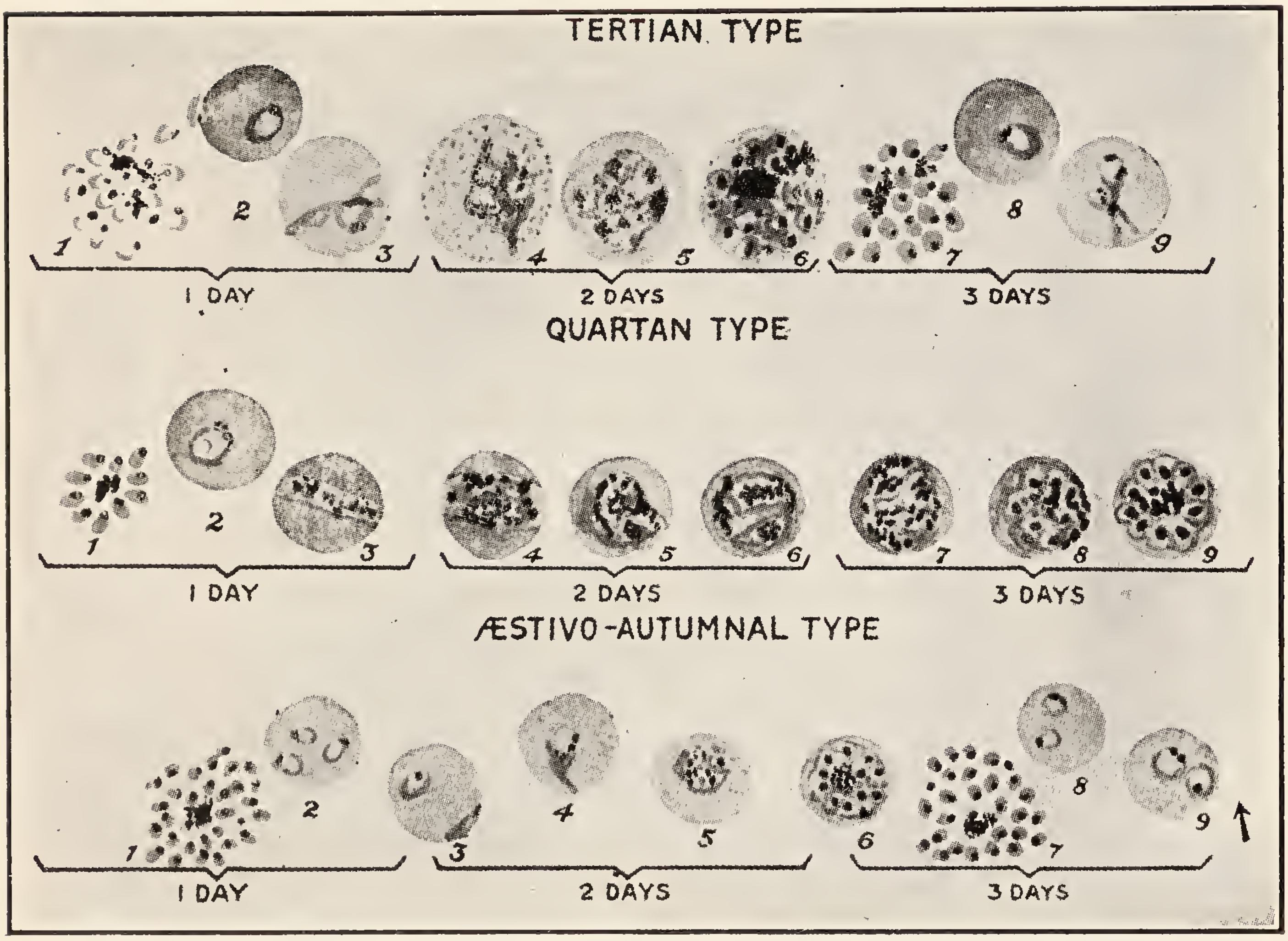

Fig. 42.—Tertian, quartan and æstivoautumnal type. Malarial parasites within the red blood cells, in various stages of development.

parasites in the blood. They can be found by examining either fresh preparations or stained specimens. In the former the parasites can be seen inside the red blood-corpuscles as colorless bodies containing granules of pigment that are in active motion. In the stained specimens the parasites are motionless, but are much more distinctly seen.

Prevention.—The spread of malaria is controlled by all measures that aim at the extermination of the mosquito. As the mosquito lives and breeds in swamps and ponds, attention should be directed to these places first. The larvæ from which the mosquito develops live and grow near the surface of stagnant water. If oil is spread on the water the larvæ cannot hatch out into mosquitoes. Swamps, when it is practical to do so, should be drained or filled in. In districts where malaria is known to exist, the house should be screened.

People with chronic malaria frequently have relapses. During the relapse they become carriers so that mosquitoes may become infected from them. Carriers must receive treatment during relapses in order to make them non-infectious.

TRYPANOSOMES.

Morphology.—A trypanosome is a long micro-organism with spirally twisted body. On one side is a membrane the edge of which is cord-like and extends beyond the body to form a whip or flagellum. The wave-like movements of the membrane and the movements of the flagellum propel the trypanosome about. The protoplasm is granular and contains two nuclei. Reproduction takes place by a longitudinal splitting of the whole cell body. The life cycle is not clear, but in some species at least there is development in an intermediate host, generally some species of fly.

Transmission of the Disease.—There are about sixty species of trypanosomes, many of which are pathogenic for animals but only two are known to cause disease in

man. The *Trypanosoma gambiense* is the cause of sleeping sickness, a disease prevalent in equatorial Africa.

The natural hosts of the parasite are the crocodile, antelope, and other big game animals. A species of fly, the tsetse fly, feeding on these animals, becomes infected and the parasite undergoes a cycle of development in

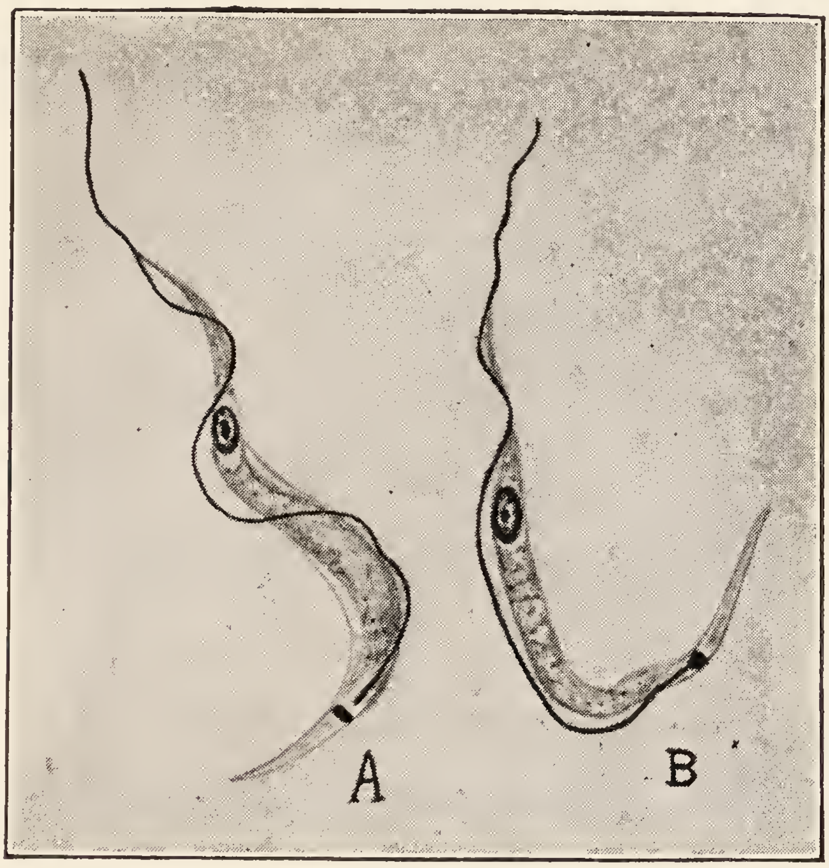

Fig. 43.—Trypanosoma Lewisi. *A,* organism with parabasal seen from side; *B,* organism turned so as to show parabasal from the end. (Zinsser, redrawn from *Minchin.* D. Appleton & Co.)

the body of the fly. After about three weeks the fly is able to transmit the infection, when it bites human beings. Trypanosomiasis or the sleeping sickness, is a chronic disorder marked by fever, wasting, and lethargy. The parasites can be found in the blood but more often in the cerebrospinal fluid. No way of establishing immunity is known.

Questions in Review.

1. In what ways do protozoa differ from molds, yeasts and bacteria? Define a protozoon.

2. Describe an ameba. How does it move and how does it multiply?

3. What type of ameba causes infection in human beings? What symptoms are produced by it?

4. Where does amebic dysentery prevail? What is the most serious complication?

5. How may the condition be diagnosed?

6. Where does malaria prevail?

7. What are the three types of malarial parasites?

8. Why do the paroxysms of fever vary with each type?

9. Explain how the infection is transmitted.

10. Why is anemia always present in malaria?

11. How is the disease diagnosed?

12. What are the methods of prevention in malaria?

13. Describe the appearance of a trypanosome?

14. Where is the trypanosome of sleeping sickness found in nature? What is the intermediate host?

15. Where is the parasite found in human beings?

16. Where does sleeping sickness prevail?

CHAPTER XIX.

DISEASES CAUSED BY UNKNOWN MICRO-ORGANISMS.

Under this head are placed a number of diseases in which no microorganism has been definitely demonstrated as the cause.

MEASLES.

Measles is a contagious and infectious disease that generally occurs during childhood, although adults may contract it. The incubation period is from seven to fourteen days. It spreads with great rapidity and generally in epidemics. The specific agent of infection is probably inhaled, causing the first symptoms to appear in the nose and throat. This is followed by the characteristic rash.

Path of Infection.—The infectious material is undoubtedly in the secretions of the nose and throat of the sick patients. It may be spread by the attendants of the patient, by furniture, hangings, carpets, by flies and insects. In preventing the spread of the disease special attention should be given to destroying the secretions from the nose and throat, which are very infectious at the beginning of the sickness. These should be collected in paper bags and burned. The patient should be quarantined until the skin and mucous membranes are clear. After recovery, the room should be disinfected. Children who have been exposed to the infection should be kept out of school during the period of incubation.

Immunity.—Immunity follows measles. The blood serum of convalescent patients contains substances that protect against the disease. Convalescent serum, as it is called, is now used in prevention and treatment. It is given intravenously. Measles is a serious disease. Like influenza, it seems to lower the resistance, making the patient susceptible to complications and other infections as well.

Rubella or German Measles.

The infection is very much like measles, but is usually not so severe. In preventing its spread the same precautions should be taken as in measles.

VARIOLA OR SMALLPOX.

Symptoms.—Smallpox is an acute infectious disease characterized by sudden onset, chills, headache, fever, and a skin eruption that passes successively through the stages of papule, vesicle, pustule, and crust, and usually leaves a depressed scar. The infectious agent is in the pustules, secretions, excretions, and in the breath. The scales are particularly infectious, forming a part of the dust in the room and becoming attached to the furniture, hangings, and clothing. The poison is very tenacious and remains virulent for months. The organism causing smallpox has long been sought for but never found. The streptococcus causes a secondary infection in smallpox but is not the cause.

Precautions.—In caring for smallpox patients the first thing to do is to isolate them, preferably in a building removed from other dwellings, because of the possibility of the virus being carried in the air. The strictest

quarantine should be enforced not only of the patients, but of the attendants. Everyone that has been exposed to the contagion should be vaccinated and kept under observation for sixteen days. During the illness the discharges from the mouth, nose and intestines should be disinfected. The quarantine must be maintained until the skin is entirely free from crusts and scales.

Immunity.—The methods and principles of immunization to smallpox have been described under the subject of immunity. Vaccination is compulsory in New York State for all children attending school. The results of vaccination have been remarkable. Smallpox, existing as a scourge for many years before the Christian era and down to the time of Jenner in 1796, has been practically obliterated in civilized countries. Vaccination alone has done this.

CHICKEN-POX OR VARICELLA.

This is an acute infectious disease of children characterized by a mild fever and a papular skin eruption. It is spread in the same manner as smallpox, but to prevent its spreading the precautions need not be so rigidly enforced because it is not so serious an infection. The patient is kept from contact with other children, and after recovery the room should be disinfected. Immunity follows the attack.

RABIES OR HYDROPHOBIA.

Transmission.—Rabies is a disease common among animals, particularly dogs, although cats, cattle, and horses may be infected. It is transmitted from one animal to another, and to man through the saliva from

the bites of rabid animals. The poison acts upon the tissues of the brain and spinal cord, being carried there along the nerve trunks. The incubation period is usually from forty to sixty days. In wounds about the head and neck the incubation period is shortest.

Symptoms.—In animals the disease begins with a stage of excitement and restlessness, followed by depression, difficulty in swallowing, and paralysis. In man there is first headache and depression; later difficulty in swallowing, and spasm of the muscles of respiration. The spasms are very painful and may be induced even by the sight of water. This is the origin of the name hydrophobia, which means fear of water. After these symptoms have developed the disease is fatal.

All efforts to find the cause of the infection in the brain and spinal cord have been fruitless. Peculiar bodies, called Negri bodies, are quite constantly found in the brain and spinal cord, which many believe are parasites belonging to the animal kingdom, and classed as protozoa. The diagnosis of rabies can be made either by finding the Negri bodies or by reproducing the disease in rabbits by inoculating them in the brain with portions of the spinal cord of rabid animals.

Immunity.—It is due to the studies of Pasteur that we are able to immunize against rabies. The usual incubation period is from forty to sixty days. Pasteur found that the virus of rabid dogs could be intensified by inoculating a series of rabbits until the incubation period could be shortened to six or seven days. The spinal cords of rabbits inoculated in this way contain the virus in its most concentrated form, and is spoken of as the fixed virus.

The fixed virus may be attenuated by drying the spinal cords and, if human beings are now inoculated with portions of this tissue, beginning first with the most attenuated and then with more and more virulent tissue, an active immunity is established before the incubation period is over. This is the method now in use in the treatment of persons who have been bitten by rabid dogs, and it can be applied during the forty to sixty day incubation period. It has proven very successful. In the last ten years 50,000 people have been immunized in this way, with failure in only 1 per cent. In cases of dog bites where there is a suspicion that the animal is rabid the wound should be cauterized with pure nitric acid. *The animal should not be killed* but kept in confinement. If it is rabid it will develop unmistakable symptoms and die in five or six days. The whole head of the animal should be sent at once to the nearest laboratory where a search for the Negri bodies can be made and the diagnosis established.

ACUTE RHEUMATIC FEVER.

This disease is generally conceded to be infectious, but the cause is as yet unknown. Several kinds of bacteria, among them the streptococci and staphylococci, have been described as its cause. They have been cultivated from the joints, blood, tonsils, and heart-valves of rheumatic fever patients. An infection very much like rheumatic fever has been produced by inoculating animals with the cultures. It is not certain, however, whether these organisms are present as the actual cause of the disease, or only as secondary invaders.

MUMPS.

This is an acute, infectious, disease affecting the salivary glands in infants and young adults. It is contagious, being spread directly from one patient to another. The infectious agent is unknown.

TYPHUS FEVER.

Typhus fever is a disease of filth. It has caused extensive epidemics, and during the war was widely prevalent in the armies of the East. It is an acute infection with sudden onset, high fever, a hemorrhagic rash, and nervous symptoms. It terminates quickly by a crisis usually at the end of the second week.

Transmission.—Typhus is transmitted by body lice. It is for this reason that it is spoken of as a disease of filth. The organism causing typhus is not positively known. Numerous organisms have been found in the blood of typhus patients but none have withstood all the tests that would prove it to be the infecting agent.

Prevention.—Inasmuch as lice are the only known carriers of the infection, delousing is the chief weapon of prevention. Lice live and lay eggs on clothing. To destroy them all clothing should be sterilized in autoclaves by steam under pressure. People should take hot showers, with soap, while the clothing is being sterilized. Immunity follows an attack of typhus and is permanent.

Questions in Review.

1. How is the infectious agent of measles spread?

2. Why are the complications of measles serious?

3. Why is the blood serum of convalescents used in prevention and treatment of measles?

4. What precautions should be taken to check the spread of the disease?

5. What are the symptoms of smallpox?

6. Where is the infectious agent found in the body during smallpox?

7. What precautions should be taken with smallpox patients?

8. What is the reason for making smallpox vaccination compulsory for school children?

9. What animals are susceptible to rabies? What tissues are attacked by the infectious agent?

10. What symptoms are produced (*a*) in animals, (*b*) in man?

11. What are Negri bodies and what is their significance?

12. Describe the method of immunization against rabies?

13. Why should an animal suspected of having rabies never be killed?

14. Why is acute rheumatic fever supposed to be an infectious disease?

15. Why is typhus fever said to be a disease of filth?

16. What is meant by a disease terminating by crisis?

17. What preventive measures are used against typhus?

CHAPTER XX.

THE TECHNIC OF PREPARATIONS FOR AND THE COLLECTION OF MATERIAL FOR BACTERIOLOGICAL EXAMINATION.

It is not strictly a part of the nurse's work to collect specimens for bacteriological examination, but sometimes the occasion arises when the nurse can render valuable assistance by knowing how to do these things. On the other hand the preparation of the patient for bacteriological procedures, such as punctures for aspirating fluids and the making of cultures from the circulating blood, is quite properly within the duties of the nurse. The directions that follow will serve as a guide, but may need to be modified or changed according to the ideas of the physician in attendance. Specimens of every kind should be accompanied by the name of the patient, the time collected, and the kind of examination desired.

THE COLLECTION OF SPECIMENS.

The Collection of Urine.

A sterile test-tube plugged with cotton is used to collect the urine, and the urine must be obtained by catheter. The usual technic is followed in preparing the patient, the catheter introduced, and the first part of the urine allowed to escape. The cotton plug is now twisted out of the tube, the mouth of the tube passed through the flame of an alcohol lamp, and the urine allowed to fill the tube one-half or three-fourths full.

The stopper is then replaced and the tube kept in the upright position.

Sputum.

Specimens to be examined for tubercle bacilli should be collected in clean, wide-mouthed bottles that can be tightly corked to prevent leakage. If the outside of the bottle has been soiled by the sputum, it should be washed off with a 5 per cent. solution of carbolic acid. Sputum to be examined for the pneumococcus, influenza bacillus, and other organisms should be collected in sterile wide mouthed bottles. Only sputum coughed up from the lower air passages and unmixed with saliva, should be sent.

Feces.

The stool may be passed directly into a sterile fruit-jar or into a sterile bed-pan and then transferred either by pouring or with a sterile wooden spatula. If the stool is to be examined for typhoid or dysentery bacilli, dip a sterile cotton swab into the stool and place into a sterile test-tube plugged with cotton. Test-tubes containing sterile 30 per cent. glycerine are provided by the New York State Health Department for the collection of typhoid stools. If amebæ are suspected the stool should be kept as near body temperature as possible and submitted to the laboratory without delay.

Blood for Widal Reaction.

The blood is obtained best by pricking the lobe of the ear with a needle having a cutting edge. The skin should be cleansed with alcohol, and the needle must

be sterile. The best way to collect the blood is in a capillary glass tube by placing one end in the drop of blood and lowering the other end enough to allow the blood to flow in easily, until the tube is one-half full. If a capillary tube is not at hand, the blood may be collected on a glass slide or on glazed paper, like a calling card. The blood drops should not be smeared out but allowed to dry as drops.

Throat Cultures.

Outfits for making throat cultures are supplied by the Bureau of Health in most cities, and consist of a sterile swab in a test-tube and a tube of culture medium. The patient is placed in a good light, the tongue held down by a tongue-depressor or spoon-handle, and the swab rubbed over the inflamed part of the throat. The material on the swab is then rubbed directly over the surface of the culture medium. After use the swab may be burned or replaced in the tube and sent with the culture.

Pus.

When the amount of the pus is sufficient, it may be collected directly into a sterile test-tube. If cultures are made, the swab and culture tube of a throat-culture outfit may be used. The pus is collected on the swab and then rubbed over the culture medium, just as in making a throat culture.

Milk and Water.

Specimens should be collected in glass-stoppered bottles, of 4- or 6- ounce capacity, which are sterile.

Specimens of milk should be well mixed before the sample is taken. Specimens of both milk and water must be kept cold and, if it is necessary to send them any distance, they must be packed in ice.

TECHNIC OF MAKING PREPARATIONS.

Aspirations and Blood Cultures.

The preparation of the patient for the aspiration of fluid from the body cavities, for lumbar puncture, and cultures from the blood must be performed with the greatest care, to insure the patient against infection and to prevent the contamination of the specimen with other bacteria, particularly those in the skin.

For aspirations of the chest or joints and for lumbar puncture, the skin should be cleansed with soap and water and then tincture of iodine or mercurochrome applied. In taking cultures from the blood this method is not always suitable, because the tincture of iodine or mercurochrome discolor the skin so much that the veins cannot be seen clearly. The veins usually selected are at the bend of the elbow. The skin is cleansed first with green soap and water, then with alcohol and ether. A towel wet with bichloride of mercury is placed over the skin and allowed to remain for one hour. Before the culture is taken the skin is again washed with ether. A bandage or piece of rubber tubing is placed somewhat above the elbow, tight enough to cause the veins to stand out so that they can be more readily punctured. The blood is drawn into a sterile glass syringe and introduced directly into the culture media.

Specimens of spinal fluid should be delivered to the laboratory as quickly as possible in order that the leucocytes, which degenerate quickly, may be counted.

Fluid aspirated from the chest, joints, or peritoneal cavity should be well shaken to prevent the fluid from clotting.

LABORATORY EXERCISES AND DEMONSTRATIONS

LABORATORY EXERCISES AND DEMONSTRATIONS

INSTRUCTION FOR NURSES.

1. Put nothing in the laboratory in or near your mouth.

2. Keep all test-tubes plugged with cotton and in the upright position.

3. Hold test-tubes to be inoculated or from which cultures are to be made, in the left hand between the thumb and the first finger with the open end pointing to the right. Remove the cotton plugs with the right hand, twisting out the plugs, and hold them by the exposed ends between the second and third and third and fourth fingers of the left hand. Flame the open ends of the tubes in the Bunsen burner.

4. Before and after making cultures or removing any growth from cultures, burn off the nichrome or platinum wire inoculating needle in the Bunsen flame.

5. When a culture tube or petri dish culture is broken, pour bichloride of mercury solution 1: 1000 or 1 per cent. lysol solution over it.

6. Never pour or throw anything into the sink. A jar containing disinfectant solution will be provided for this purpose.

7. At the end of each period wash the hands with soap and water and rinse in a 1: 1000 solution of bichloride of mercury.

SUPPLIES AND INSTRUMENTS NEEDED FOR LABORATORY EXERCISES.

It is recommended that two nurses work together. Each two should have:

1. One nichrome wire inoculating needle and loop.
2. A Bunsen burner or alcohol lamp.
3. A test-tube rack large enough to hold twelve tubes.
4. Two large glass tumblers of heavy glass with a pad of cotton in the bottom for holding culture tubes.
5. A supply of glass slides, cover glasses and filter paper.
6. One microscope with high and low power dry lenses and oil immersion lens.
7. Two hanging drop slides.
8. Stains should be kept at a central point in the laboratory near a sink. Culture media, petri dishes, and test-tubes may be issued as needed.
9. For demonstration purposes there should be on hand cultures of the *Staphylococcus albus* and *aureus, Streptococcus hemolyticus, Bacillus pyocyaneus, Bacillus typhosus* and *Bacillus subtilis.* Smears of sputum containing tubercle bacilli and pneumococci and smears of pus containing gonococci will be needed. A blood smear containing malarial parasites will also be needed.

The demonstrations at the end of each laboratory period are intended to be made by the instructor.

Demonstration preparations may be obtained from:

E. Leitz & Co., 60 East 10th St., New York City.

The Will Corporation, Rochester, N. Y.

A. H. Thomas Co., West Washington Square, Philadelphia, Pa.

The General Biological Supply House, 761-763 East 69th Place, Chicago, Ill.

EXERCISE I.

1. The microscope. Demonstration of its various parts. How it is used. The use of the fine and coarse adjustments of the focusing tube. How to use the reflecting mirror and the iris diaphragm. The purpose of the Abbé condenser. How to clean the lenses and how to lift and carry the microscope.

2. Place tiny shreds of paper, linen and cotton on a slide and examine with the low power lens. Strip a very thin piece of skin from the inner part of an onion. Place it in a drop of water on a slide and cover it with a cover glass. Gently press it down. Place a drop of weak eosin solution at the side of the cover glass and draw the stain under by means of a strip of filter paper on the opposite side. Examine for cell structure.

Make drawings of objects seen.

EXERCISE II.

1. Practice focusing with the oil immersion lens on smears of molds made by taking a loopful of the mold growth from moldy bread or agar plates that have been exposed to the air and mixed with a drop of water on a slide.. Dry gently above but not in the Bunsen flame. Stain with Löffler's methylene-blue solution for one minute. Wash off the excess stain in water, blot with filter paper and examine.

2. Prepare a solution of fresh yeast by mixing a small fragment of fresh yeast cake in a third of a test-tube of water. One tube of this mixture will suffice for the class. Place a loopful of the mixture on a cover glass, the edges of which have been greased with vaseline. Now invert the preparation over the concavity of a hanging drop slide, taking care to press down the edges to exclude the air and prevent evaporation of the drop. Examine with the high dry lens and draw the yeast cells seen.

3. Demonstrate stained smears of staphylococci, streptococci, diplococci, spirilla and bacilli.

4. Demonstrate the various methods of sterilization: Flaming, dry heat, boiling, live steam (Arnold sterilizer), and autoclave. Explain the uses of each method.

NOTES.

EXERCISE III.

1. Make smears from between the teeth using a sterile swab or tooth pick. Rub the end of the swab or tooth pick on a glass slide. Fix by heat over the Bunsen flame and stain for one minute with Löffler's methylene-blue solution. Wash in running water, blot dry with filter paper. Examine with the oil immersion lens, draw and classify the various bacterial forms seen.

2. Make a smear from a culture of the B, subtilis by taking a minute amount of the culture on the sterile inoculating needle and mixing with a drop of water on a glass slide. Fix by heat. Stain with Löffler's methylene-blue solution for one minute. Wash and blot dry. Examine for spore formation and make drawings.

3. Demonstration: Show the various types of culture media, solid and fluid, and explain their uses.

4. Show the method of making streak and stab cultures on solid media, streak cultures on agar plates and the transplanting of cultures from one medium to another.

EXERCISE IV.

1. Make a hanging drop preparation of a broth culture of the B. subtilis, using the technic described in Exercise II, and observe the motility.

2. Inoculate two tubes of nutrient broth, one with *Staphylococcus albus* and one with B. subtilis. Incubate 24 hours and keep for next period.

3. Make a broth culture of the B. coli and another of the *Staphylococcus albus.* Incubate for 24 hours and keep for next period.

4. Demonstration: Show pigment formation in agar cultures of the *Staphylococcus aureus* and *citreus* and the *Bacillus pyocyaneus.*

NOTES.

EXERCISE V.

1. Place the cultures of the B. subtilis and the *Staphylococcus albus,* made at the last period in a water bath and boil for 5 minutes. Make subcultures of each in fresh nutrient broth and incubate for 24 hours. Keep for next period.

2. Make thin smears on glass slides of the cultures of the B. coli and the *Staphylococcus albus,* made at the last period. Dry and fix by heat.

3. First demonstrate the Gram stain, using the following technic:

Stain for two minutes with Stirling's gentian violet, freshly prepared. Blot dry.

Flood the smear with Gram iodine solution (iodine crystals 4.0; potassium iodide 8.0; distilled water 400.00 cubic centimeters) for 1 minute. Blot dry.

Decolorize the preparation with 95 to 100 per cent alcohol and wash in running water. Blot dry. Counterstain the preparation with 10 per cent. safranin solution for thirty seconds and wash. Blot dry and examine.

Have each nurse repeat this procedure, making the smears and carrying out the stain.

4. Demonstration: Show fermentation by inoculating one fermentation tube containing glucose broth with B. coli and another with B. typhosus. Incubate for 24 hours and keep for next period.

EXERCISE VI.

1. Note the results of the subcultures of the B. subtilis and the *Staphylococcus albus* made at the last period and explain the results.

2. Observe the results of the fermentation tests made with the B. coli and the B. typhosus at the preceding period and explain the results.

3. Stain prepared smears of pus containing the gonococcus by Gram's method to show the Gram-negative diplococci within the pus cells. (Care must be taken not to decolorize with the alcohol too long. The nuclei of the pus cells should be blue and the gonococci red in a perfectly stained preparation.)

4. Hold an open agar plate before the mouth and cough at it. Incubate the plate for 24 hours and keep for next period. Repeat this experiment, coughing through a sterile mask or gauze from the operating room.

5. Demonstration: Show the capsules of the pneumococcus in sputum from a pneumonia patient. Have the slide prepared in advance.

NOTES.

EXERCISE VII.

1. Observe the agar plates made at the last period. Explain the result and draw practical conclusions from the standpoint of asepsis in the operating room.

2. Melt six tubes of plain agar in a water bath. Pour the contents of each tube into a separate petri dish and allow them to harden. Inoculate as follows:

(*a*) Place a hair on the surface of a plate and replace cover immediately.

(*b*) Smear the surface of a plate with scrapings from beneath the finger-nails made with a sterile orange stick.

(*c*) Wash the hands in soap and water in the ordinary way. Dry the hands on a towel and touch the finger tips to the surface of a plate.

(*d*) Wash the hands with green soap in hot running water. Scrub the hands for five minutes with a brush, rinse and put the hands into 1 : 1000 bichloride of mercury solution for 5 minutes. Touch the surface of an agar plate with the finger tips.

(*e*) Keep one plate unexposed for a control. Incubate all plates for 24 hours and keep for the next period.

3. Make a culture of the B. coli into a tube of nutrient broth and incubate for 24 hours. Keep for use at the next period.

NOTES.

EXERCISE VIII.

1. Observe the results of the cultures made on the agar plates in the preceding period. Draw conclusions from the standpoint of operating room technic.

2. From the broth cultures of the B. coli, made at preceding period, make inoculations into four tubes containing respectively, 10 cubic centimeters of 5 per cent. carbolic acid solution; 10 cubic centimeters of 1 : 1000 bichloride of mercury solution; 10 cubic centimeters of 2 per cent. mercurochrome solution, and 10 cubic centimeters of sterile distilled water. After 5 minutes make subcultures, using one loopful of each of the above solutions, into sterile broth tubes. Incubate for 24 hours and keep for the next period.

3. Demonstration: Prepare, for use at the next period, streak cultures of hemolytic streptococcus on blood agar plates. Incubate for 24 hours.

NOTES.

EXERCISE IX.

1. Observe the results of the cultures made at the last period. Make smears on slides from each culture, fix by heat and stain with methylene-blue solution for one minute. Examine with the oil immersion lens and note the results.

2. Have the members of the class make throat cultures on each other. With the "patient" close to a window and facing the light, hold the tongue down with a tongue depressor in the left hand. This will make it possible to see the tonsils and pharynx. Gently rub the sterile swab over the surface of the tonsils and throat. After removing the plug from the culture tube containing Löffler's coagulated blood serum, rub the swab thoroughly over the medium. Incubate the culture for 24 hours. Place the swab after using in a solution of bichloride of mercury.

3. Demonstration: Show under the microscope stained smears of the B. diphtheria. Show hemolysis on blood plates made at last period.

EXERCISE X.

1. Make smears from the throat cultures of the last period. Fix and stain with Löffler's methylene-blue solution for one minute. Wash and examine under oil immersion lens. Note the organisms found.

2. Demonstration: Prepare in advance an agglutination reaction with typhoid immune serum and the B. typhosus (Widal reaction) in dilutions of 1 : 20, 1 : 40, and 1 : 80.

Use the following technic: Grease three cover glasses for making hanging drops. Place one loopful of typhoid immune serum on a slide and add nine loopfuls of sterile broth medium. Mix thoroughly. Take three loopfuls of this mixture and add three loopfuls of broth and mix thoroughly. Take two loopfuls of the second mixture and add two loopfuls of broth and mix thoroughly. This makes three dilutions, 1 : 10, 1 : 20 and 1 : 40 respectively.

Place one loopful of each dilution on a cover glass and add one loopful of fresh broth culture of B. typhosus that has been incubated 18 hours. Invert cover glasses on hanging drop slides. This makes the dilutions 1 : 20, 1 : 40 and 1 : 80. Mix and incubate for one hour. The preparation is now ready to examine for agglutination of the typhoid bacilli.

A drop of the typhoid culture in hanging drop may be used as a control.

3. Demonstrate the *Treponema pallidum* either in stained smears or in tissue stained after the method of Levaditi.

4. Show malarial parasites in stained blood smears.

NOTES.

EXERCISE XI.

1. Make smears of sputum containing tubercle bacilli or issue smears already prepared for staining. Stain, using the following technic:

Cover the smear with Ziehl-Neelsen's carbol-fuchsin solution, gently steam the preparation by means of the Bunsen flame for 5 minutes. Take care that the stain does not dry on the slide. Wash in water. Decolorize the preparation with acid alcohol (95 per cent. alcohol with 3 per cent. hydrochloric acid) until the preparation is colorless. Wash in water. Counterstain with Löffler's methylene-blue solution for 20 seconds and wash in water. Blot dry and examine with the oil immersion lens. The tubercle bacilli will be stained red and the remainder of the specimen will be blue.

2. Demonstration: Show how the pasteurization of milk is done in the home.

Visit a modern milk distributing plant to see how large quantities of milk are pasteurized. How the bottles are cleaned, filled, and capped. Have the method of direct bacterial count demonstrated and the Babcock test for the estimation of fat.

NOTES.

EXERCISE XII.

1. Put 10 cubic centimeters of sterile distilled water into each of three sterile test-tubes with a sterile 10 cubic centimeter pipette. Thoroughly mix the contents of a bottle of raw market milk by inverting it twenty times.

With a sterile 1.0 cubic centimeter pipette, graduated into tenths of a cubic centimeter, put one-tenth of a cubic centimeter of the milk into one tube of sterile water. Mix by gently shaking. Take one cubic centimeter of this mixture and add it to the second tube of water. Mix. Take 1 cubic centimeter of this second mixture and add it to the third tube of water.

Place one-tenth of a cubic centimeter of each mixture into a petri dish, using a fresh sterile pipette for each one.

Melt three tubes of agar. Cool to 44° C. and pour the three plates. After the media has become solid, label each plate and incubate for 24 to 48 hours. Repeat this experiment using pasteurized or certified milk.

NOTES.

EXERCISE XIII.

1. Note the results of the milk plating done at last period. Count the number of colonies, calculate the dilutions and determine the number of bacteria in 1 cubic centimeter of the raw and pasteurized milk.

2. Inoculate three agar tubes that have been melted and cooled to 44° C. with 1 cubic centimeter of water from the following sources: Surface water, public drinking supply and sterile distilled water from the operating room. Pour plates and incubate.

3. Visit water filtration plant to see how it is operated.

NOTES.

EXERCISE XIV.

1. Observe plates made from water at the last period. Count the colonies and draw conclusions.

2. Demonstration: Show the various kinds of immune sera and vaccines and describe the way they are administered.

A motion picture film showing the process of making immune sera and vaccines has been prepared by Parke, Davis & Co. of Detroit, Mich., and may be obtained from them for demonstration purposes.

NOTES.

EXERCISE XV.

1. Visit a public health laboratory or the hospital laboratory to see how the Wassermann test is set up. Observe results of test. See how the Kahn test is done and observe the end results.

2. Demonstrate the various containers and outfits supplied by the hospital and public health laboratory for the collection of specimens for examination.

NOTES.

GLOSSARY

Abrasion. A spot rubbed bare of skin or mucous membrane.
Accessory sinuses. Cavities in the bones of the skull, some containing blood and some air.
Acid fast. A term applied to bacteria that resist decolorization with acids.
Aërobic. Requiring air or free oxygen for growth.
Agar. A type of sea-weed containing a gelatin like substance, used in making solid culture media.
Agglutinin. An antibody that has the power of clumping bacteria.
Agranulocytic angina. An ulcerative condition in the mouth or throat accompanied by reduction in the number of granular leucocytes.
Allergy. Hypersensitiveness of the body to foreign protein.
Amboceptor. A thermostabile substance which on combination with complement and antigen causes cells to dissolve.
Anaërobic. Able to live only in the absence of free air or oxygen.
Anaphylaxis. Hypersensitiveness to antitoxins and serums.
Aniline dyes. Colors derived by chemical process from coal tar.
Anemia. A condition in which the blood is lacking either in quality or quantity.
Aneurism. Localized dilatation of an artery due to injury or disease.
Angina. Sore throat. Pain.
Animalcules. Very small animal organisms.
Anterior poliomyelitis. Infantile paralysis.
Antibody. Substances that protect from an infecting agent.
Antigen. Any substance that produces antibodies.
Antitoxin. A proteid substance developed in the body of man or animals that has the power of neutralizing poisons.
Arsphenamine. A preparation of arsenic used in the treatment of syphilis.
Arthritis. Inflammation of a joint.
Attenuation. The diminished power of an organism to produce disease.

Bacillus (pl. **bacilli**). A rod-shaped organism belonging to the vegetable kingdom.
Bactericidal. Possessing the power of destroying bacteria.
Bacterins. Killed bacteria suspended in fluid and injected under the skin in the treatment of some diseases. Also called vaccines.

Bacteriology. The study of bacteria.

Bacteriolysins. Substances developed in the body which are capable of dissolving bacteria.

Bacterium (pl. **bacteria**). A unicellular organism belonging to the vegetable kingdom.

Binary fission. The method of multiplication of bacteria in which the organism splits in half.

Carbohydrates. A compound composed of carbon, hydrogen, and oxygen. Starches, sugars, etc.

Carrier. A person, not sick with any disease, who carries disease-producing organisms in the body and is capable of infecting others with them.

Cell. The smallest unit of structure in plant and animal life.

Cellulitis. An inflammation in the soft tissues of the body.

Chancre. The primary sore at the point of infection in syphilis.

Coccus. A bacterium having a spherical shape.

Colony. A mass of microorganisms of the same kind that has developed from one organism.

Contagion. The transmission of disease by mediate or immediate contact.

Cubic centimeter. Fifteen drops.

Culture. A mass of microorganisms growing on laboratory culture media.

Cystitis. Inflammation of the urinary bladder.

Deodorant. A substance that destroys objectionable odors.

Dick test. Cutaneous reaction for susceptibility to scarlet fever.

Disinfectant. A physical or chemical agent that destroys bacteria.

Emphysema. The distension of tissue with air or gas.

Empyema. A collection of pus in the pleural cavity.

Endemic. A term used to designate a disease that exists all the time in a locality.

Endocarditis. An inflammation of the lining of the heart.

Endotoxin. A poison retained in the body of a bacterium and set free when the bacterium disintegrates.

Enzyme. An unorganized ferment formed in the bodies of plants and animals capable of splitting complex substances into simpler forms without being changed itself.

Epidemic. An infectious disease affecting large numbers of people in a locality at the same time.

Erysipelas. An acute spreading infection in the skin.

Etiology. The study of the cause of disease and the way disease is transmitted.

Fermentation. The decomposition of complex substances into simpler forms by the action of a ferment.
Flagellum (pl. **flagella**). A whip-like process extending from the body of a bacterium which propels the organism about.
Filtration. The passage of fluid through a filter to remove the solid particles.
Filtrate. The fluid that comes through in the process of filtration.
Fusiform. Pointed at each end.

Gram. Equal to fifteen grains.

Hemoglobin. The coloring matter contained in the red blood corpuscles which gives the blood its red color.
Hemophilic. Having an affinity for blood.
Hemolysis. The solution of red blood cells.

Immunity. The resistance of the body to disease.
Incubation. The period between the entrance of disease producing bacteria into the body and the signs and symptoms of disease. Cultivation of bacteria at body temperature.
Infection. The entrance into the body of bacteria resulting in injury or disease.
Infectious diseases. Diseases caused by living organisms.
Inhibition. The arrest or restraint of bacterial growth.
Inoculate. To put infectious material into the body to produce disease or into culture media to produce bacterial growth.
Intraspinal. Within spinal canal.
Intravenous. Within vein.

Larva (pl. **larvæ**). The stage of insect development after it leaves the egg in which it resembles a worm.
Lesion. An abnormal condition of any tissue or organ due to injury or disease.
Leucocyte. The white corpuscle of the blood.
Luetin reaction. A skin test for the detection of syphilis.
Lumbar puncture. The introduction of a needle into the space around the spinal cord for the removal of the cerebrospinal fluid.

Malaise. Feeling sick.
Medium (pl. **media**). The material used for the cultivation of bacteria.
Meningitis. An inflammation of the membranes covering the brain and spinal cord.
Microorganism. An organism visible only under a microscope.
Morphology. The study of the form and structure of bacteria.

Motile. Possessing power of locomotion.
Mucous membrane. The soft, mucus secreting lining of body cavities.
Mycelium. The thread-like processes of fungi.

Necrosis. The death of tissue.
Negri bodies. Minute bodies found in the brain of persons and animals infected with rabies.
Nucleus (pl. **nuclei**). The spherical body found in cells which controls its life and activity.

Opisthotonos. A posture characterized by arching of body so that it rests on the heels and back of head.
Opsonin. A substance in the blood serum which makes bacteria more easily absorbed by the leucocytes.
Orchitis. An inflammation of the testicles.
Organic. Relating to substances derived from living organisms.
Osteomyelitis. An inflammation of the medullary cavity of bone.
Otitis media. An inflammation of the middle ear.

Pandemic. A term applied to the existence of an infectious disease throughout the world.
Papule. A small, solid elevation of the skin.
Parasite. A plant or animal that lives on or in another living organism.
Paresis. A progressive, general, paralysis due to syphilis.
Pasteurization. The arrest of bacterial growth by heat.
Pathogenic. Disease producing.
Phagocyte. The white blood corpuscle of the blood that envelops and destroys bacteria.
Pigment. Coloring matter.
Pericarditis. An inflammation of the covering of the heart.
Pseudopod. A transient protrusion of the protoplasm of an ameba.
Protoplasm. A jelly-like, structureless, substance found in all living cells.
Protozoön (pl. **protozoa**). A unicellular animal organism.
Prophylaxis. The prevention of disease.
Ptomaine. Partially decomposed proteid.
Pyogenic. Pus producing.
Puerperal fever. An infection starting in the uterus after childbirth.
Pustule. A small elevation of the skin containing pus.
Pyogenic. Causing the formation of pus.

Quarantine. Isolation on account of suspected contagious disease.

Saprophyte. An organism capable of living on dead matter.
Schick test. A skin test used to detect those susceptible to diphtheria.

Septicemia. The condition resulting from the invasion of the body by bacteria and the absorption of the poisons produced by them.

Serum. The fluid portion of blood present after clotting.

Spirochete. A spiral or corkscrew-shaped organism.

Sporadic. The term applied to infectious diseases that occur at irregular intervals.

Spores. A form assumed by some bacteria to resist unfavorable influences.

Sterile. Free from microorganisms.

Suppuration. The formation of pus.

Tenesmus. Ineffectual straining at stool.

Ticks. Blood sucking insects.

Toxin-antitoxin. A mixture of diphtheria toxin and antitoxin used to immunize against diphtheria.

Toxin. A poison formed by living organisms.

Tuberculin. A preparation made from tubercle bacilli and containing their toxins.

Vaccine. Killed bacteria suspended in fluid.

Vesicle. A small elevation of the skin containing serum.

Vacuole. A cavity in the protoplasm of a cell.

Virus. An animal poison capable of producing disease.

Virulence. Disease-producing power of bacteria.

Wassermann reaction. A blood test for the detection of syphilis.

Widal reaction. A blood-test for the detection of typhoid fever.

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